GEOGRAPHICAL REVIEW

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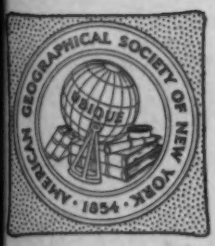

OCTOBER
1937

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THE GEOGRAPHICAL REVIEW

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ORIGINS OF THE GREAT WALL OF CHINA
A FRONTIER CONCEPT IN THEORY AND PRACTICE

Owen Lattimore

THE Great Wall of China developed out of an earlier system of walled frontiers to which relatively little attention has been paid,[1] though notable advances have been made in recent years, especially by Chinese research workers, in textual criticism, in the geographical identification of early place names, and in clarifying the historical sequence of relations between the Chinese and various "tribal" peoples.[2] It is now possible to use this rich critical and documentary material to carry speculation and discovery a stage further.

What factors in the society of China promoted the development of the Great Wall form of frontier delimitation? Once the main line of the Great Wall had been established, implying the concept that the Frontier should be absolute and immovable, does the working of any of the factors that can be detected in agriculturally based China and in the nomadic pastoral society of the steppe help to explain the way in which, through century after century of the ebb and flow of conquest, this inherently permanent kind of frontier was obliterated, reëstablished, and modified?

[1] For an introduction to the subject see Hsü Chü-ch'ing: Peipien Ch'ang-ch'eng K'ao (A Study of the Northern Frontier Great Walls), *Shih-hsüeh Nien-pao* (*Historical Annual*) of the Historical Society of Yenching University, No. 1, 1929. See also Wang Kuo-lang: Chung-kuo Ch'ang-ch'eng Yen-ko K'ao (Study of the Development of the Great Wall), Shanghai, [1928?]. The numerous line maps are especially useful, but the author tends to be overbold in his conclusions. The best atlas is Ou-Yang Ying: Chung-kuo Li-tai Chiang-yü Chan-cheng Ho-t'u (Chinese Historical Atlas of Administrative Boundaries and Wars), 3rd edit., Wuchang, 1933. See also Albert Herrmann: Historical and Commercial Atlas of China, *Harvard-Yenching Inst. Monograph Ser.*, Vol. 1, Cambridge, Mass., 1935 (reviewed in the *Geogr. Rev.*, Vol. 27, 1937, pp. 515–517). I am especially indebted to Mr. T'ung Kuei-t'ing of Tsing Hua University for a survey (in manuscript) of recent Chinese publications and for help in checking references to the older sources.

[2] See, for instance, the files of the *Yü Kung* (*Chinese Historical Geography*) published in Peiping by the Chinese Society of Historical Geography. An important attempt to redefine the broad tribal and geographical categories of the non-Chinese peoples with whom the Chinese dealt in preclassical times was made recently by Fu Ssu-nien in his "I Hsia Tung Hsi Shuo (East and West Theory of the I and Hsia)," in "Ch'ing-chu Ts'ai Yüan-p'ei Liu-shih-wu Sui Lün-wen Chi (Studies Presented to Ts'ai Yüan-p'ei in Honor of his Sixty-fifth Year)," Academia Sinica, Peiping, 1936, Vol. 2, pp. 1093–1133.

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When the question is put in this light, it brings two major problems into view. In the first place, the history of "the" Great Wall concerns the relationship between "civilized," agricultural China and the "barbarian" peoples of Central Asia, Mongolia, and Manchuria, chiefly pastoral in economy but partly of forest origin.[3] In the second place, the earlier systems of frontier walls that preceded "the" Great Wall cannot be attributed entirely to the wars between Chinese and "barbarians." Among the earliest of them were walls that ran north and south, between one Chinese state and another. There was even a wall blocking the approach from the Yellow River to the Yangtze Valley, between the headwaters of the Han River and those of the Huai, which divided the dominant southern state of Ch'u from the states of North China.

Chinese Bias Toward Rigid Frontiers

At this point a double working hypothesis may be stated, corresponding to the double problem just presented. There must have been something inherent in the historical processes of the state in China that favored the evolution of walled frontiers, irrespective of hostile relations between the Chinese and peoples whose ways of life were incompatible with theirs; and this bias toward the evolution of rigid frontiers must have had something to do with the factor of range. It must have been a lack of confidence in their range of action that prompted the statesmen of China to build walls that limited their own expansion as well as defending them against attack. This factor of range was not constant in either time or place. It must be assumed that economic, social, and political developments making possible a great increase in range of action contributed to the rise in China of an imperial state, superseding the small national states of the classical period. Thereafter a limited range of action continued to constrict Chinese expansion along the northern frontier, but in the south the Chinese kept up throughout ensuing history and still keep up today a gradual but massive advance, carrying with them Chinese forms of agriculture and assimilating, socially, the non-Chinese peoples encountered.

It was only in the north that the effort to maintain a rigid frontier persisted. The history of the Great Wall frontier between China and the northern barbarians can therefore be said to have perpetuated the working of those forces within the society of China that were responsible, in an earlier phase, for the building of walls between separate national states in China. At the same time, the political

[3] The Manchus, for instance, were a forest people in the beginning. For the partly forest origin and forest-hunting economy of the Mongols before Chingghis Khan see B. Y. Vladimirtsov: Obshchestvennyi stroi mongolov: Mongol'skii kochevoi feodalizm (Social Structure of the Mongols: Mongol Nomadic Feudalism), Leningrad, 1934.

uses of a rigid, walled frontier were adapted to suit the geographical cleavage between the river basins of China, with their intensive economy of agriculture, especially irrigated agriculture, and the steppe regions of the north, with their extensive pastoral economy. This distinction holds as a general rule, though the character of the regions north of the Great Wall was modified in the east and north by forests that favored a hunting economy and, in places, the special nomadism of reindeer breeders (in the northern zones of Manchuria, Mongolia, and Urianghai, approximating to Siberia in climate and other characteristics). In the west it was modified by the oases of Chinese Turkistan, which favored an agriculture quite as intensive as that of China, but only on a minuscule scale, not sufficient to make a foundation for large national states. The social geography of agricultural, pastoral, and hunting peoples must therefore be kept in mind, as well as the physical geography of the great rivers and plains of China, the mixed forests, watered plains, and steppes of Manchuria, the steppes of Mongolia (giving way to forests in the north), the oases and deserts of Chinese Turkistan, and the especially high and cold plateau of Tibet.

As there is not room in one article for the comprehensive treatment of the subject,[4] I shall confine myself here to the briefest possible mention of the early phase of walled frontiers in China and then discuss more fully the interaction of social and physical geography in the history of the unified Great Wall frontier.

China of the Feudal States

In the classical period of Chinese history, which is generally considered to run from the twelfth to the third century before Christ, and in a somewhat vaguer way even in the preclassical period,[5] China was nominally an empire, in which the real political power belonged to a number of relatively small states. This was a China that hardly reached to the Yangtze Valley. Its component states are usually called "feudal," a description that serves well enough, with the reservation that the characteristics that make it possible to use the

[4] The material here presented forms part of a general study of "The Inner Asian Frontiers of China," on which I have been engaged for some years. Field work, linguistic studies, and research into source materials have been supported by the Social Science Research Council, the Harvard-Yenching Institute, and the John Simon Guggenheim Memorial Foundation, as well as by grants from the American Geographical Society and the Royal Geographical Society. A first volume is now being prepared for publication, with the support of the Research Council of the Institute of Pacific Relations.

[5] By the excavations at Anyang, in Honan, much new material has been added for the study of the preclassical period as far back as the fourteenth century before Christ (approximately). For the inscriptions and other material of this period the chief sources are the publications, in Chinese, of the Academia Sinica. The most recent publication in English is H. G. Creel's "The Birth of China," London, 1936, which has a bibliography of Chinese sources. See also "Soldier and Scholar in Ancient China" by the same author (*Pacific Affairs*, Vol. 8, 1935, pp. 336–343). For the dating of the oldest Chinese history see pages 242 and 246 of C. W. Bishop: The Chronology of Ancient China, *Journ. Amer. Oriental Soc.*, Vol. 52. Bishop's conclusions are accepted by K. A. Wittfogel in his "The Foundations and Stages of Chinese Economic History," *Zeitschr. für Sozialforschung*, Vol. 4, Paris, 1935.

term "feudalism" in referring to the history of both Asia and Europe were to a certain extent balanced by differentiating characteristics, the importance of which increased as the evolution of China diverged from that of Europe.

In the period of the Contending States, from the fifth to the third century before Christ, the separate feudal states developed with increasing momentum from their old, feudal form to a new, national form. In this process the weaker states were absorbed by the more powerful contenders. Political unification was at first more rapid in the south, which may not have been due to earlier maturity but to the lack of an economic and social framework strong enough to maintain separate national states. As a consequence of this the state of Ch'u, based on the Yangtze, extended its conquests north to the territory between the Han and Huai Rivers two or three generations before the achievement of centralized unity in the north, where power was divided among several states, which built walls against one another as well as against the "northern barbarians." Then, in the third century before Christ, the state of Ch'in, standing not at the geographical heart of Chinese historical development but on the northwestern rim of it, subordinated all the quasi-national states and created in a crude form the imperial, dynastic, bureaucratically

FIG. 1—China at the end of the period of Contending States and the beginning of the Ch'in Empire, third century before Christ, showing frontier walls: 1, northern proto-Great Wall of Ch'u; 2, southern proto-Great Wall of Ch'i; 3, northern proto-Great Wall of Yen; 4, western proto-Great Wall of Wei; 5, southern proto-Great Wall of Wei; 6, northern proto-Great Wall of Chao; 7, northern proto-Great Wall of Ch'in (pre-imperial); 8, supplementary post-imperial Great Wall of Ch'in (Ninghsia region); 9, supplementary post-imperial Great Wall of Ch'in (Manchurian region); 10, eventual main line of "the" Great Wall. Scale of map approximately 1:30,000,000. (Based on Ou Yang Ying and Herrmann, see footnote 1.)

administered state that from that time on was the dominant political form in Chinese history. From that time on, moreover, wall building ceased within China and became associated exclusively with the steppe frontier, though the political frontier never became so rigid as the delimitation of it by wall fortifications would indicate.

Agricultural Foundations and Social Forms

This political outline only hints at the social history that must be understood if the romantic picture of Chinese and barbarians, eternally divided by a wall, is to be given depth and real meaning. For the constructive approach that is necessary, the work of Wittfogel is of capital importance,[6] providing the clearest analysis we have of the geographical framework within which the society of China originated and matured. The loess country of Shensi, he points out, in the valleys of the Wei and other streams tributary to the middle Yellow River, favored an early development of agriculture with even the most primitive tools, because the soil never carried a heavy forest growth to be cleared off. The agriculture of this region tended, moreover, to develop the technique of irrigation while still at a primitive level, because the chemistry of the loess soil is such that it needs only water to maintain its fertility, and the rainfall of the region is irregular,[7] so that only irrigation can supply water at the right time as well as in the right quantity. Small irrigation ditches could be made even with stone tools, by the people of one family.

When the society that grew up on these foundations began to expand into the lower Yellow River Valley, it found conditions that were different, but not too different. Irrigation was less important than the building of dikes to limit floods and ditches to drain marshes. It was easy to adapt to these purposes not only the technique developed by irrigation enterprises in the loess country but the social forms that had been promoted, in an agricultural community, by the importance of engineering problems. Technical improvements, moreover, had from the very beginning a social effect; social forms in turn, as they grew and matured, showed an affinity for particular aspects of agriculture and technique, the elaboration of which was fostered at the expense of alternative aspects.

Irrigation and drainage could be originated on a primitive scale of family labor, but they could not change the agricultural character of wide regions except by collective labor. The society that eventually

[6] K. A. Wittfogel: Wirtschaft und Gesellschaft Chinas, Part 1 (Schriften des Instituts für Sozialforschung an der Univ. Frankfurt a. M., Vol. 3), Leipzig, 1931; also his "Foundations and Stages of Chinese Economic History" (cited in footnote 5).

[7] "In Northwest China, where the normal rainfall is about 250 mm., it is as likely as not that the next year's rainfall will be as low as 160 mm.; hence the chances of a farmer in that region for getting a good crop without irrigation are very meager indeed" (Coching Chu: The Aridity of North China, *Pacific Affairs*, Vol. 8, 1935, pp. 206–217; reference on p. 217).

made itself permanent in China was therefore one that provided large reserves of man power for public works, notably by means of unpaid *corvée* labor. The family system encouraged the production of children at a rate that ensured a plentiful and cheap supply of man power. This, in turn, both minimized the demand for labor-saving machinery and promoted the application of human labor for intensive agriculture. Grain was the basic commodity, and the accumulation and storage of grain made possible the calling together of laborers by the thousand to work on irrigation and drainage projects. The enlargement of irrigation canals to serve also as transport canals made the transport of grain cheaper, at the same time that it discouraged the development of roads. Whereas, therefore, grain was eventually transported over very great distances, in order to provide a sufficient accumulation at the capital city,[8] commerce as a whole, except for a few commodities like salt, tea, and iron, was conspicuously an exchange, over short distances, of agricultural produce and the artisan manufactures of provincial cities. In the political landscape of China, as a consequence, the rural village has always been dominated by the walled city, set in the country and not very distant—in some places reached by a journey of only a day or two, over bad roads, according to the intensiveness of agriculture and the density of population—from an exactly similar walled city.

The Walled City in the Political Structure

The primary standard in range of action, economic and social, political and military, is therefore the walled city. The later evolution of national states was accomplished by creating a "royal" pyramid, at the base of which was a group of small regional units, each dominated by a walled city. It was the effort to make these larger units as permanent as the walled city unit that led to the building of the early "Great Walls," dividing state from state and also, on the north, dividing agricultural China and its walled-cities from the open steppe, in which were neither walled-cities nor rivers to supply irrigation nor canals for the transport of grain. This phase marked only a temporary uncertainty in the process of evolution. It was followed by the creation of an even more massive, "imperial" pyramid of power, based on a still broader unification of homogeneous regions and walled cities. It was then no longer necessary to build walls dividing regions. Internally there remained only walled cities, externally the Great Wall, defending agriculture from the people of the steppe.

From the survival of the walled city it can be seen that imperial unification never wholly superseded the cellular structure of small regional units. This was in part because the social order had evolved

[8] Ch'ao-ting Chi: Key Economic Areas in Chinese History, London, 1936.

ruling families entrenched in a special position, which they were able to maintain even in the face of the imperial interest and its demand for centralized authority. It was by combining a professional standard of qualification for office with the principle of family succession (although without the hereditary titles that distinguish a feudal aristocracy) that they maintained themselves. To begin with, public works carried out by forced labor were beyond the scope of even the largest feudal landholders. They demanded a professional class of administrators. It may be noted in passing that the complicated checking, tallying, rationing, and other record-keeping activities probably favored, as in Egypt, the development of a "professional," excessively complicated method of writing, which enabled the scribes to create and hold a position apart from the rest of society.[9] The higher positions in this class offered employment for the members of what had been the feudal aristocracy. Out of this there grew a class of wealthy, landowning families that, generation after generation, entered some of their sons in official life as professional administrators, while the family itself remained a landholding unit. Rent income, the perquisites of office, and the ability, as members of both the landed gentry and the professional bureaucracy, to avoid the full weight of taxation and demands for labor[10] thus formed a triple standard of economic and social power.

Range of State Action

When all the characteristics thus far mentioned are gathered together, it is possible to see that the range of state action in China was a function of the relatively good working order, at any given moment, of the following: an intensive agriculture, made more intensive by public works in irrigation, drainage, and transport by water, producing a grain surplus the concentration of which determined the concentration of political power; long-range export of agricultural surplus for storage in imperial granaries and local, short-distance exchange of most of the necessaries of life between rural districts and provincial, regional cities (each of which was also a fortified stronghold, with the result that the standard of military maneuver was relatively cumbersome and immobile); a social system in which land was the unit of wealth but not of power, because neither the regional power of the landed gentry nor the metropolitan interests of the imperial court could operate independently of the professional class of scholar-bureaucrats, who in their own persons and also in their administrative routine interpenetrated and adapted to their own uses both gentry and dynasty.

[9] Wittfogel, Foundations and Stages of Chinese Economic History, p. 54.

[10] For the survival of these phenomena into the modern phase see Wang Yü-ch'üan: The Rise of Land Tax and the Fall of Dynasties in Chinese History, *Pacific Affairs*, Vol. 9, 1936, pp. 201–220.

An empire of such structure could expand indefinitely, as long as new territory could be acquired in homogeneous units, each with its short-range economy of local exchange between country and city and each with a surplus for long-range contribution to the imperial centers of grain accumulation and garrison concentration. The rice culture of the Yangtze Valley and the south, although differing in important details from the millet and wheat culture of the north, could meet the same need for a swarming peasant class and a self-selecting, self-perpetuating professional bureaucratic class, interlocking with the landed gentry. Expansion toward the south became therefore a regular Chinese occupation, which went on during the collapse of dynasties as well as during periods of strong imperial unification. Only in the north were both expansion and defense repeatedly frustrated, and the geographical and social aspects of this political impotence must now be examined.

Unification of China into an Empire State

A great increase in range of action was the prime characteristic of the unification of China, in the third century before Christ, under Ch'in Shih Huang Ti, the "First Emperor." He put an end to the separate nation-states, proving that it had become possible to extend the geographical base of government and at the same time to raise it to a higher stage of development, through greater concentration of economic strength and the employment of "professional" administrators instead of hereditary feudal retainers.[11] He abolished the need for internal walled frontiers and unified and refortified the northern walled frontiers defending China from the barbarians. The possibility of thus extending the base and raising the height of the pyramid of government had been maturing for centuries, but the rapidity with which it was realized, by the conquests of Ch'in Shih Huang Ti between 238 and 220 B.C., must have been, for the people of the time, overwhelming. They were, in fact, stunned by it; a generation passed before the full response to the new possibilities could be expressed, and in that generation the Ch'in dynasty fell, almost with the death of its founder. The Han dynasty, which replaced it,[12] made permanent the positive changes achieved by Ch'in Shih Huang Ti but was in the main a response to the new potentialities of empire that the smashing Ch'in conquests had opened up and by no means a simple continuation of the process of conquest.

The excessive military emphasis in the Ch'in conquests was the cause of this reactive pause of break and modified renewal. The military strength of Ch'in was the striking arm of an economic system

[11] For an account of one of the most important of these "professionals" see J. J. L. Duyvendak: The Book of Lord Shang: A Classic of the Chinese School of Law, London, 1928.

[12] Earlier, or Western, Han, 206 B.C.–A.D. 23; Later, or Eastern, Han, A.D. 25–220.

and a social and administrative organization that had been elaborated to the point where full use of their potentialities demanded wider areas and increased centralization. The all-inclusive conquests of Ch'in Shih Huang Ti destroyed the balance between the economy and society and their mobilized military power, by first reaching and then passing the limit of coördination between the military power of the state and its administrative power of integration. The resistance of the states it was trying to conquer made the military expansive power of Ch'in work closely together with its administrative power of integration. With the success of conquest and the disappearance of opposition, they began to diverge. Conquest became a process in itself, impossible to halt or stabilize. The resultant strain was too much for the fabric of the new empire, which therefore collapsed, though its military power was unchallengeable.

Conquest Overreaches Limits of Stability

It may be said that any state able to store up a reserve of energy is capable, theoretically, of expansion or conquest in a ratio proportionate to the reserve accumulated. The use of this power, however, is conditioned by the character of the territory to be acquired. Depth of penetration into the margin of possible conquest must be calculated in terms of the ability to rule as well as the ability to conquer. The profits of conquest depend on the degree of economic and social compatibility or disparity between the state system of the conquerors and the territory and society which they attempt to subordinate. Because of the complicated way in which apparent military strength is thus modified, it is rare for a movement of conquest to strike the optimum between insufficient expenditure of energy and a disastrous overexpenditure. This is one explanation of the way in which a victorious nation can collapse as if it had been defeated. If it falls short of the conquests it could have made, it may have to fight a series of wars; but if it develops too much momentum and overpasses the margin, an apparently successful war or series of wars can be followed by sharp and even disastrous internal reactions.

This was what happened as a result of the Ch'in victories, and the reaction was enhanced because Ch'in stood on the northwestern rim of the civilized world of China, so that its empire had to be created by a drive inward, causing a shift in the center of gravity. It had to "centralize" from a distant frontier position. Partly because of this, administrative centralization could not keep up with the thrust of military conquest, with the result that in the effort to convert the power of the state from a phase of expansion to one of stabilization the empire began to crack apart along the line reached by administrative centralization but far overpassed by military conquest.

This was in the general region of the Huai basin, intermediate between the valleys of the Yellow River and the Yangtze. To the north lay the region where the staple crops were millet (several varieties) and wheat; for this agriculture both irrigation and drainage were valuable auxiliaries, in the use of which the society of Ch'in was not greatly different from those of the other states of the region, though more advanced in development. To the south stood the territory of Ch'u, the last state to hold out against Ch'in. Rice was the staple of its agriculture,[13] and its technical development was therefore somewhat different from that of the north, though not incapable of being combined with it, later, in an all-inclusive Chinese agrarian economy based on both millet and rice and competent to handle a great variety of technical problems in irrigation, drainage, terracing, the prevention of floods, and the building of transport canals. Ch'u had to a certain extent anticipated Ch'in in developing toward a supra-national, imperial form of state, and although in the final contest the military victory went to Ch'in, because its maturing political development was integrated with an economic progressiveness and a social evolution more advanced than those of Ch'u, even Ch'in was not yet strong enough to assimilate the somewhat different worlds of North and South China (for Ch'u was then the South) into a single empire.

North and South

The troubles that attended the fall of the first inclusive imperial dynasty had therefore in part the character of a reaction of the South against the North and, in part, in the North itself, the character of a reaction of the center against the periphery. In this manner it was left for the Han dynasty, founded in 206 B.C., to weld together the cleft between North and South, reassert the center against the periphery, and so reshape the imperial state in an abiding form. When this had been done the rice lands of the South lay open for Chinese penetration to an indefinite depth. The technique of adding to the intensive agriculture of the North the still more intensive agriculture of the South and the society based on it had been mastered. The grain surplus exacted as imperial tribute could be transported, eventually, over vast distances. The theoretical optimum of expansion thus became progressive, the determining factor being the strength of the centralized imperial state.

By the determination in this manner of northern political orientation toward the South, the North itself became marked off from the "barbarian" steppe more clearly than ever before. This can be seen from the way in which the compact, well coördinated administrative

[13] Compare, in addition to Wittfogel, C. W. Bishop: The Beginnings of North and South in China. *Pacific Affairs*, Vol. 7, 1934, pp. 297–325.

and military power that had originally made possible the Ch'in rise to power overreached itself in frontier expansion. Its failure here was different in kind from its partial failure to bind the Yangtze Valley to North China. In the North the factor of social strength was permanently biased by an imperative geographical factor. The steppe, as such, demanded of any Chinese who entered it a social modification divergent from the main trend of Chinese development, with the result that the Chinese of the Frontier were fated to vacillate, for twenty centuries and more, between orientation toward the tribal power of the steppe and orientation toward the agriculturally based, dynastic-imperial civilization of China itself.

Part of the strength of Ch'in, at the time of its final drive toward empire, had been due to the way in which it was poised almost exactly along the line of optimum expansion along the Frontier. The heart of its territory was the Wei basin, in modern Shensi. In southeastern Kansu, in the semioasis Ninghsia region, and along the edge of the true steppe in the Ordos loop of the Yellow River it had established a frontier position facing the barbarians of the steppe. Many of the lands thus occupied were marginal, both because they belonged originally to pastoral, barbarian, non-Chinese tribes and because the soil, climate, and water supply permitted either an extensive, pastoral economy or an intensive, agricultural economy. In such a situation the political factor was decisive, and it was the political accretion to Ch'in of so much tribal blood that gave it a permanent name for barbarity in Chinese history.

This has always obscured the really creative achievement of Ch'in, during its initial period of conquest. It succeeded, in a marginal territory, in diverting nomadic, pastoral tribes toward an intensive economy and a "Chinese" line of evolution that eventually proved completely dominant over the racial or linguistic or cultural heritage of the tribes themselves, though these characteristics lasted long enough to affect the people of Ch'in with an un-Chinese tinge that offended the more cultured people living in the center of what was then the Chinese world. Yet we can now see that the Ch'in line of evolution combined the sinicization of border peoples with an advance toward a logical improvement of the Chinese state itself and so made it possible to draw strength from the Frontier instead of having to divert strength to the defense of the Frontier. While it lasted, this condition must have contributed, to a degree that we can now hardly calculate, to the reserve strength of Ch'in.

Men and Tactics in a Frontier State

In order to understand both this period, when Ch'in needed to grasp only at points well within its reach along the frontier, and the

subsequent period, when the need for stabilization forced it to overreach its grasp, the careers of two famous men of the state of Chao may be cited.

The state of Chao (Fig. 1) held the northern part of the modern Shansi in the period of the Contending States, which ended in the Ch'in conquest. It was more or less permanently at war with northern barbarians of a steppe-nomadic type and built for defense against them a wall that later became part of the Great Wall. Wu Ling, who ruled Chao between 325 and 298 B.C. and built this wall, did not limit himself to a static defense. He "changed the customs [of Chao], wore the costume of the Hu [nomad barbarians], and trained cavalry and archers." On one campaign he "set out, dressed as a Hu, at the head of his war councilors, to the northwest and won possession of the Hu territory in that region, with the intention of making an attack southward . . . to invade Ch'in." Most astonishing of all, he even presented himself, disguised as a tribal envoy, before the ruler of Ch'in, in order to form a personal judgment of his character.[14]

Li Mu, lord of the north of modern Shansi under Hsiao Ch'eng, ruler of the state of Chao from 265 to 244 B.C., was a frontiersman of the same kind. He stationed officers to collect the land taxes, which were brought to the camps to pay for keeping up the army. For the feeding of his troops he slaughtered cattle daily, and he trained his men in riding and archery. By the use of signal towers he was able to concentrate his forces where necessary. In one border campaign he spread herds of cattle out over the country, to make it look undefended. This was reported by small parties of nomads (evidently riding in to trade along the border), and the barbarians were tempted to try a raid. In this way they were drawn into ambush and defeated with the loss of more than 100,000 men. The resultant extension of frontier control then brought Chao into contact with tribes that had formerly been considered outlying.[15]

These records clearly describe a border territory of scattered agriculture and mixed economy, in which the troops were not entirely flour-fed, for a large regular meat ration is emphasized. Mounted archery was the standard of efficiency, and border defense was not strictly of Great Wall type but mobile and adaptable to rapid concentration. The troops were so far habituated to a life approximating that of the nomads that they were even eager to take the offensive in nomad territory. The border conditions were those of a nomad

[14] See Chapter 43 of the "Shih Chi (Historical Memoirs)" of Ssu-Ma Ch'ien, p. 152 of Vol. I of the K'ai Ming edition of the "Erh-shih-wu Shih (Twenty-five (Dynastic) Histories)," Shanghai, 9 vols. of text and 1 vol. index of names; index dated 1935. See also J. J. M. de Groot: Die Hünnen im vorchristlichen Zeit, Vol. 1, pp. 34–35, quoting this chapter.

[15] "Shih Chi," Ch. 81, p. 206 of Vol. 1 of the K'ai Ming edition of the "Twenty-five Histories." Compare De Groot, *op. cit.*, Vol. 1, pp. 37–39. See also the long extract from the biography of Li Mu in L. Wieger: Textes historiques, 2 vols., Hien-hien, 1929, Vol. 1, pp. 195–196, where, however, the source is not indicated.

society—free passage for small parties of men but not for bodies large enough to be dangerous. The mixed, partly pastoral economy is further indicated by herds large enough to invite the raids of nomads and to mask the front of an army. When the Chinese took the offensive, they used the tactics of pure nomadic warfare—swift movement in open country, maneuver, ambush, and sudden assault.

Chao, it is plain, was a Chinese frontier state, modified by contact with nomads in a territory in which intensive, irrigated agriculture was not the standard of taxation and administration. In the southern part of Shansi it held the Fen Valley, one of the oldest centers of irrigation in China, but the effect of its frontier expansion was to draw it away from this agricultural base and therefore away from the main trend of economic and social evolution in China. The army won victories, but the state perished, because although China as a whole was gravitating toward the center and toward the creation of a new centralized, inclusive state form, Chao was gravitating toward the frontier, the pull of which promoted a devolution toward a more extensive economy, running counter to the general Chinese evolution of political forms based on increased intensification.

The inference from this and from the history of Ch'in itself is that, although Ch'in also expanded along the Frontier, it did not overreach itself, at first, to such a degree as to be dragged away from the course of typical Chinese development. On the contrary, the Ch'in sector of the Frontier itself gravitated toward the center, being brought into the Chinese line of evolution, so that when the full limits of favorable frontier expansion had been reached, Ch'in was able to turn without a pause and bring its whole weight to bear in China, without being weakened by overexpansion into the kind of marginal territory that favored devolution toward an extensive economy and away from political centralization. This does not mean that Ch'in was not itself modified by the successful way in which it consolidated a frontier position. We know that the Ch'in cavalry had a partly tribal character; it was one of the "un-Chinese" things in Ch'in that account for the Chinese dislike of Ch'in (a permanent historical tradition) as the uncouth destroyer of all that was feudal, traditional, and conservative. The truth seems to be that the "barbarism" of Ch'in was the result, not of the barbarization of its Chinese population, but of the rapid enlistment of tribal groups that were in process of being converted into Chinese of the new order at the same time that they were being used to destroy the old Chinese political and social order. It is quite possible that they had a special historical function, in that their adjustment to progressively developing Chinese conditions prevented vested interests from stratifying, stimulated innovation, and promoted the evolutionary changes inherent within the Chinese agricultural economy and society.

Frontier Pull and Frontier Pressure

When it had conquered China, the new empire of Ch'in had to brace itself with comparative suddenness against the pull of the frontier away from the new centralization in China. For I think it can be demonstrated that, when Ch'in linked up the existing northern border walls into the first Great Wall, it prevented further accretion to its own strength by the enlistment of peoples of mixed economy living in marginal territories. Such peoples, no longer able to evolve toward assimilation into China, because of the attempt to fix a rigid frontier, felt intermittently the political and military pressure of tribes living in the far steppe, who led an unmodified pastoral nomadic life, based on the most extensive livestock economy. Adherence to these tribes promoted devolution away from the Chinese course of development. Chinese ascendancy along the Frontier meant that the Chinese frontiersmen themselves developed antievolutionary, anti-Chinese characteristics. This was a tendency that increased in proportion to the depth of the Chinese penetration into marginal territories that resisted the introduction of the irrigated, intensive agriculture and the "cellular" structure of dense rural populations grouped around walled cities, which underlay the social canons and political practice of the state in China. From the time of imperial unification under Ch'in through the following centuries of the cyclical rise and fall of dynasties, I think it is necessary to count on this frontier *pull* as well as on the frontier *pressure* of tribal barbarians, which ranged from local raids to invasion and conquest. If this is true, then it must be further said that the well known process of the "sinicization" of barbarian invaders meant the slackening of frontier pressure and the resumption of the frontier pull away from the center, so that it did not solve the frontier problem of China but converted it into an alternative form.

The Ch'in unification of the Great Wall Frontier, by acquiescing in the development of a special frontier population, not wholly Chinese in its characteristics, compromised the idea of rigidity that was essential to the Great Wall theory of frontier delimitation. It exceeded the effective range of action of the newly established imperial state, which overreached itself along the Great Wall as it did in the transitional territory between the Yellow River and the Yangtze, making it possible for disruption to begin under the feet of the successful conquerors.

Repeated Failure To Hold the Ordos

The First Emperor and his greatest lieutenant, Meng T'ien, undertook both to establish a wall system that would halt invasion and to create social conditions that would supply man power for

garrisoning the Great Wall. This was to be done by welding to the edge of the new empire and the society that was being standardized within it a marginal, debatable land, never yet held permanently by either Chinese or barbarians, which for centuries had been known as the Huang Fu or Steppe Dependency.[16] The entire Ordos plateau steppe was colonized by 30,000 Chinese families and the new frontier sector linked by road with the Ch'in capital, in the Wei basin.

Because of the temporarily irresistible military power of Ch'in, it was possible to clear the ground of tribal opposition; but for permanent success nothing less was required than the implantation of the Chinese agricultural economy in a terrain that had resisted it for centuries and that was different in soil and water supply from the regions in which the Chinese methods had been developed. Moreover, the expansion was attempted at a time when the society based on the Chinese economy had been newly raised to a higher level of development, requiring increased specialization in the intensive methods of the older agriculture. The whole project, therefore, relied on weight of military power to push through an agricultural expansion that could succeed only if it consented to devolve toward extensive agriculture, and even a mixture of herding and farming, though the colonists were drawn from a society that had just been politically forced to accept progressive evolution toward an increasingly intensive agriculture, virtually without herding. This involved the anti-historical paradox of attempting two mutually exclusive forms of development simultaneously.[17]

The result was failure. Within a century the barbarians, by then known politically as the Hsiungnu, had retaken the entire Ordos. The Han dynasty, which had once more united China, basing its military power on a more stable balance between the Yellow River and the Yangtze Valleys than had been possible for Ch'in Shih Huang Ti, had to cope afresh with the frontier problem. In 128 B.C. a Han statesman advised the emperor against attempting to conquer the Hsiungnu. He pointed out that the Ordos project of Ch'in Shih Huang Ti had added to the empire a territory "marshy, salt, and unsuitable for agriculture," to which it was necessary to transport grain and forage "by sea and by the rivers of the north." The difficulties were so great that only a thirtieth part of the supplies arrived (the rest being consumed in transit); and the colonists were not even

[16] Compare C. W. Bishop: The Rise of Civilization in China with Reference to Its Geographical Aspects, *Geogr. Rev.*, Vol. 22, 1932, pp. 617–631.

[17] A good chronological discussion of the steps by which Ch'in cleared the barbarian political power from what I have called the "marginal" lands of the Ninghsia-Ordos region and advanced up to the northern part of the Ho-t'ao or Ordos loop is found in Chang Wei-hua: Ku-tai Ho-t'ao yü Chung-kuo chih kuan-hsi (Connection between the Ordos and China in Ancient Times), *Yü Kung* (*Chinese Historical Geography*), Vol. 6, No. 5, Nov. 1, 1936. From such an account as that given by Mr. Chang it is only a step to the distinction that I have here made, based on the relation of society to geography, between "favorable" marginal territories with a social evolution toward China and "unfavorable" marginal territories, with the characteristic of social devolution away from China.

able to support themselves. The memorial attributed to these causes the origin of the discontent that had caused the fall of the Ch'in dynasty.[18]

Yet in the very next year, after a new Hsiungnu inroad had been stopped, not in the Ordos region but over on the eastern sector of the Great Wall Frontier, the same minister was converted to the idea of preventive colonization of the northwest, in order presumably to turn the flank of the Hsiungnu, though other statesmen still opposed the method. Accordingly, a new administrative unit was created in the region of the modern Ninghsia, under the name of Shuofang, "the Northland." Here 100,000 colonists were settled and border fortifications put in hand, and at the same time a series of offensive campaigns was begun against the Hsiungnu in Mongolia. The necessary provisioning of the colonists, before they could establish their own agriculture, was as formidable a problem as it must have been when Ch'in Shih Huang Ti and Meng T'ien attempted it. From Shantung, on the coast, supplies had to be hauled against the current of the Yellow River all the way up to the northernmost Ordos. Ordinary navigation being impossible, this had to be done by forced labor, tens of thousands of men being required to tow the barges.[19] The expense of the colonization and the campaigns therefore far exceeded the value of the results, and the "nomad problem" itself could not possibly be settled by such methods, because the Hsiungnu and after them the tribes of later historical periods, however often defeated, had an indefinite margin of retreat, reaching across Mongolia into Siberia.

Difficulties Inherent in the Frontier Zone

What was it that made the Han dynasty return to methods that had been proved inadequate under the Ch'in? The problem itself, it is evident, involved more than linking up a line of fortifications from the marches of Tibet to the Gulf of Liaotung. The true difficulty was the stabilization of a frontier society adequately adapted to the margin of the steppe and yet auxiliary to Chinese interests and secure against the drag away from China resulting from "un-Chinese" devolution toward a mixed frontier economy. Such devolution, when carried far enough, made possible social and political coalescence with the barbarians, eventually converting the drift away from China into a "tribal," military pressure inward on China. Attempts to fix a permanent degree of compromise in these mixed frontier groups could not succeed, because they presupposed a harmonization of mutually exclusive forms of development.

[18] "Shih Chi," p. 250 of Vol. 1 of the K'ai Ming edition of the "Twenty-five Histories"; also "Han Shu (Han History)," *ibid.*, p. 518 of Vol. 1. For extract (without citation of the source) see Wieger, *op. cit.*, Vol. 1, pp. 392–393.

[19] "Tzu Chih T'ung Chien," Ch. 18 (written in the Sung dynasty). For extract see Wieger, *loc. cit.*

The concept of an optimum of conquest, which in historical retrospect can be theoretically formulated, was in fact never capable of realization in frontier history. Although Chinese state theory repeatedly tried to make the Frontier an absolute line of demarcation it remained obstinately a margin or zone of differentiation. Even the southern and northern edges of this margin were not absolute but shifted according to the varying range of efficient action, in offense or defense, at different periods, of tribal society in the steppe and the agriculturally based society of China.

Impossible though it was to define or stabilize, this margin never lost significance. Tribal penetration too far to the south of it, no matter how great the momentary military strength of the conquest, was always offset, when the long-term social and economic factors resumed operation, by the sinicization of the invaders. And the Chinese could not push expansion beyond the northern edge of the margin, no matter how strong the dynasty of the time, without eventual tribalization of the most outlying Chinese and the reversion to full tribalism of the auxiliary, half-tribal groups that had temporarily been brought under Chinese control. The significance of social form in these alternations is clear; but it is also clear that neither sinicization nor tribalization was the result of an absolute "superiority" in either the civilized quality of society in China or the military qualities of the frontier tribes. Neither could function at its highest potency except inside the extremes of a margin of geographical transition.

Meng T'ien, attempting to master the Frontier for Ch'in Shih Huang Ti, so that the newly achieved empire could be confirmed and perfected in a closed world, found inevitably that the limits of an empire created by the ruthless assertion of active principles could not be safely defined by resting passively on the line of a negative, defensive, containing Frontier. To stop short on a theoretical line of cleavage was impossible, because it would have required the assumption that the positive expenditure of energy on a great scale, in moving up to the line of the Great Wall, could be stopped short without a dangerous frontier "drag," converting itself eventually into a reactive inward pressure against the center. The assertion, or confession, that the empire of Ch'in Shin Huang Ti could go no farther without weakening itself implied the corollary that the frontier peoples could attempt a counter-pressure against the Chinese.

The Great Wall Concept: Absolute and Relative

Yet China was committed, first by the Ch'in unification and then by the imperial line of development renewed under the Han dynasty, to a permanent form of the imperial state, based on a recognizable

body of economic practices and the social forms that they predicated. It could not make concessions to the geography and society of the steppe without admitting incompatible and competitive forms of state development. Obviously, therefore, a line of cleavage existed, somewhere, between the territories and peoples that could advantageously be included in the Chinese empire and those that could not. This was the line that the Great Wall was intended to define. In practice it was impossible to maintain the concept of a line that could not be crossed; what was attempted, therefore, was an easing off of the process of expansion that would keep up the appearance of a continuing outward pressure. For this, even the grandiosity of the Great Wall was insufficient. It was necessary to employ social devices that would discreetly diminish the outward thrust of the Ch'in frontier policy, without breaking it off so abruptly as to invite counterattack; and this meant the recognition of intermediate social groups that, though not fully homogeneous with the main body of China inside the Great Wall, would be amenable to Chinese control.

The Frontier Reservoir

As a result of this compromise, repeated at intervals and never fully successful, between the absolute or Great Wall concept of the Frontier and the relative or social concept, which admitted and made use of social forms intermediate between full dependence on Chinese intensive agriculture and full reliance on the extensive economy of pastoral nomadism, there arose the phenomenon that I have elsewhere described as the frontier "reservoir."[20] Its characteristics may be briefly restated as follows:

The linear Frontier never existed except as a concept. The depth of the trans-Frontier, beyond the recognized linear Frontier, made possible a historical structure of zones, which varied from time to time. These were occupied by a graduated series of social groups, from partly sinicized nomads and semibarbarized Chinese, in the zone adjacent to China, to steppe peoples in Mongolia, forest peoples in North Manchuria and Urianghai, and peoples of the plateau in Tibet, of whom the more distant were virtually unmodified by such attenuated contacts as they had with China. The oasis peoples of Chinese Turkistan formed another group, with special historical functions. Within this graduated series those groups that adjoined the Great Wall held the (inner) "reservoir" of political control over the Frontier. By origin and in function they were ambivalent social bodies, which could either serve Chinese control of the Frontier or become auxiliary to attacks on China, which originating in the (outer) "reservoir" of

[20] Owen Lattimore: Manchuria, Cradle of Conflict, 2nd edit., New York, 1935. For examples both of the Mongolization of Chinese and of the approximation of agricultural Mongols to Chinese peasants, compare Owen Lattimore: The Mongols of Manchuria, New York, 1934.

tribal conquests, in the depths of the trans-Frontier or Outer Frontier, swept with them the peoples of the inner reservoir zone or Inner Frontier.

These auxiliary peoples of the Inner Frontier are probably the least studied of the major agents in Chinese history. Being by-products of the total impact on each other of China as a whole and the Frontier as a whole, they were not genuinely rooted in either the economy and society of China or those of the forested Manchurian mountains, the steppes of Mongolia, or the Tibetan plateau. Yet it should not be assumed that they had therefore no importance of their own. In spite of their limited absolute power, they were of the greatest relative importance. In passive phases they represented the balance, at any given time, between China and the Frontier; but in active phases they were agents of ferment in frontier relations, causing new adjustments of the balance and preventing it from ever becoming static and permanent.

Because of this, it is not always necessary to search the core of China for the causes of the great periods of Chinese expansion. Nor are the origins of great nomadic conquests to be found only in the widest regions of the true steppe. For the steppe we find a wide acceptance of elaborate mechanical explanations, in the form of climatic cycles or progressive desiccation, to account for the "blind" eruption of nomad hordes.[21] For China, though its political and social history is much more adequately documented, we have equally mechanical theories of population pressure, and so forth. Such explanations are not adequate. Mature historical understanding requires full recognition of the factors of physical geography, the climatic stimulus (where it can be proved), and the character of the environment as a whole; but it also demands an appreciation of the dynamics of social groups. The geographical distinction between China, a land permitting and encouraging intensive, irrigated agriculture, and the plateau, steppe, and forest regions of the Frontier (the oasis regions of Ninghsia, Kansu, and Chinese Turkistan form a special category) not only is plain in itself but demands separate recognition of the characteristics of the social groups typical of each landscape.

Resemblance to Other Frontier Problems

Moreover, the history of the Great Wall Frontier suggests at least an outline of general principles. The problems here faced by China, in the past, have a broad resemblance to the problems with which the

[21] Perhaps the best recent restatement of these theories of geographical materialism is in the discussion of nomad migrations and conquests in Vol. 3 of A. J. Toynbee's "A Study of History," London, 1934, pp. 7–22; also his account (pp. 22–50) of the shift of the Osmanli Turks from nomadism to dominion over settled peoples and his survey (pp. 395–454) of the supposed climatic causes of "Nomad eruptions."

Romans tried to cope in building *limes*[22] (limiting walls) to set a bound to the expansion of their *orbis terrarum*, the equivalent of the Chinese *t'ien hsia*, or "all under heaven." The British empire in India is troubled by a modern counterpart of the same problem, not only in its North-West Frontier, where the Durand Line and its various alternatives of policy and method suggest an equivalent to the Great Wall of China, but also along the Tibetan frontier and that of Chinese Turkistan. The recognition by the British of an outer limit of desirable expansion is not determined simply by the physical geography of the mountains that enclose the land frontiers of India. It is directly conditioned by the fact that the Indian empire, the mastery of India itself, must for efficient administration be limited to a range of territories, economic resources, military requirements, and social classifications according to race, language, caste, and religion which, although bewilderingly diverse in detail, add up to a recognizable whole. To reach out too far beyond the periphery of this manageable whole is wasteful; yet even so, it has never been possible to keep the fringes of the Indian empire clear of external commitments in the way of tribal policy, the support of protectorates, and so on. It is recognized as "an axiom of Frontier administration that a tribe or group of tribes situated between two comparatively powerful States must be under the influence of one or other of these States."[23]

Old Problems Still Exist in Essence

The history of the Great Wall makes possible the study of problems of this category over a very long period of time and within a geographical framework that can be studied in detail. It shows us that, although the peoples of the steppe had vast military range, the economy of the steppe, even when diversified by control over oases and marginal, partly agricultural territories adjacent to the Great Wall and by the ability to draw on the economy and society of forest regions, was never rich enough in resources to make a foundation for stable, centralized empire. It shows us that China had a more limited range of military action but a much wider range in imperial administration. The internal resources of China could be so marshaled that China, at times, could reach out and attach to itself the oases of Chinese Turkistan, thus turning the flank of the steppe tribes. Yet it could never eliminate, among the marginal peoples, the wavering between devolution toward the economy of the steppe and evolution toward the economy of China and so could never put an end to the

[22] Compare the apposite use by Sir Aurel Stein in his various authoritative works on Chinese Central Asia, of the term *limes* for any of the outer fortifications built by the Chinese at different times beyond the main line of the Great Wall.

[23] Quoted from "an eminent statesman," by Sir Kenneth Wigram: Defence in the North-West Frontier Province, *Journ. Royal Central Asian Soc.*, Vol. 24, 1937, pp. 73–89; reference on p. 74.

ebb and flow of Frontier history and maintain the civilization of China in the closed world that was its ideal.

Railways and machine industry, which could not be evolved out of the civilization created within China by the Chinese but had to be introduced, have changed the ancient character of the Frontier. The range of all forms of action—economic, social, military, political, administrative—has been so immensely increased that it looks almost as though all the old problems had lost their significance. In essence, however, they are still there. Even for an industrialized society, imperialism has its point of diminishing returns; the range of action made possible by accumulation of resources and social organization for the purpose of subordinating other societies, different in organization, reaches in time a line that is likely to be vague but that cannot be crossed without overreaching the range of empire, converting accretion toward the center into a drag away from the center.

THE PIONEER FRINGE IN PALESTINE

SETTLEMENT POSSIBILITIES SOUTH AND EAST OF THE HOLY LAND

Jean Gottmann

THE last twelve years have witnessed a rapid economic development in Palestine through the men and money brought by Jewish colonization. Unhappily this development has been accompanied by political strife, even by sanguinary disorders. The task assumed by Jewish colonization—to gather together on the land of their ancestors a people dispersed two millenniums ago to the four corners of the earth—is an enterprise without precedent that cannot fail to create complex political problems.[1] The most discussed problem, constantly invoked by the Arab leaders and once again the subject of investigation by a Royal Commission, is the capacity of the land to support population. This is essentially a geographical problem.[2]

It is a striking fact that Jewish colonization is localized in certain regions of Palestine (Fig. 1): the coastal plain north of Ashkelon, the Plain of Jezreel or Emek, the Galilean plateau, the environs of Jerusalem in the mountains of Judea, the northern part of the Ghor. But on the border of these regions, to the south and east, are vast spaces where colonization has scarcely penetrated: to the south, the Negeb, which adjoins the desert of Sinai; to the east, the great trough of the Ghor and, beyond, the highlands of Trans-Jordan, which merge farther on into the Arabian deserts. These empty lands, the domain of nomads, call for pioneers seeking a "place in the sun." On the other hand, we do not believe that the regions already colonized are overpopulated—far from it.[3] It would be temerity, with the scant scientific data at our disposal, to envisage a colonization in the great Bedouin deserts as a whole; but we can attempt to sketch the pioneer fringe around Palestine. The advance already made in this direction

[1] Compare the following note on the political situation in Palestine, pp. 566–573.—EDIT. NOTE.

[2] Among works on the geography of Palestine and Jewish colonization may be cited: Ellsworth Huntington: Palestine and Its Transformation, Boston and New York, 1911; Andrée Choveaux: The New Palestine, *Geogr. Rev.*, Vol. 17, 1927, pp. 75–88; A. T. Strahorn: Agriculture and Soils of Palestine, *ibid.*, Vol. 19, 1929, pp. 581–602; F.-M. Abel: Géographie de la Palestine, Vol. 1, Géographie physique et historique, Paris, 1933; and *Palnews Economic Annual of Palestine*, published since 1935 by the Palestine News Service, Tel Aviv. Some aspects of these questions were studied in my articles "L'irrigation en Palestine," *Ann. de Géogr.*, Vol. 44, 1935, pp. 143–161, and "Orient et occident: Problèmes palestiniens," *L'Information Géogr.*, Vol. 1, 1936–1937, pp. 5–12.

[3] In an excellent abstract of my article "L'irrigation en Palestine" (see footnote 2) J. Allen Tower has misread a passage of my conclusion (Some Recent Studies of the Climate and Geography of Syria and Palestine, *Geogr. Rev.*, Vol. 26, 1936, pp. 156–158): "According to present knowledge, future rural colonization and expansion of irrigation can take place only toward the south and the east, into the more arid regions." In reality I wished to indicate that an advance in these two directions had taken shape and that there lay the great work. In the areas already colonized, industry has only made a beginning and will certainly expand, and a more complete and systematic irrigation will considerably increase the possibilities of rural settlement.

warrants such an essay. A regional analysis will permit us to lay down the general problems involved in the opening of these borderlands so coveted and so little known.

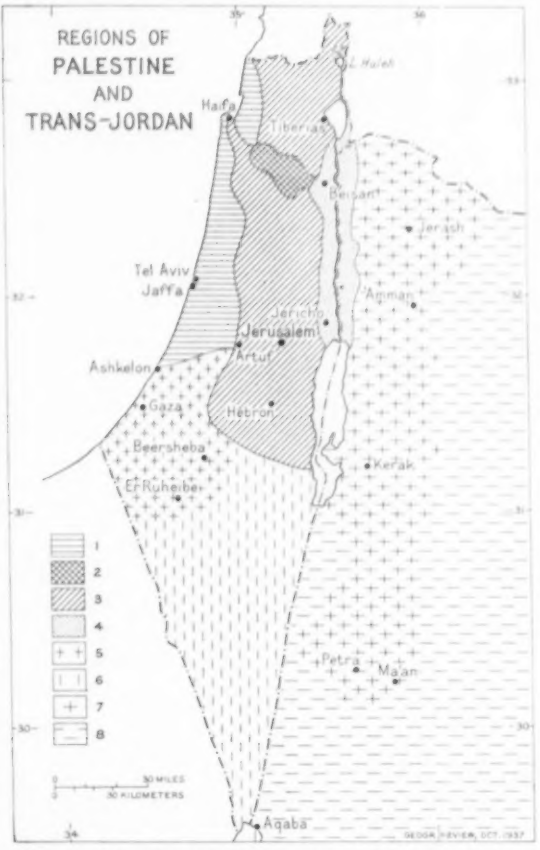

FIG. 1—Schematic map of the regions of Palestine and Trans-Jordan. Regions of present settlement: 1, coastal plain; 2, the plain of Jezreel or Emek; 3, the hill country: regions of potential settlement; 4, the Ghor; 5, the part of the Negeb where possibilities are believed to be favorable; 6, the unknown remainder of the Negeb; 7, plateaus of Trans-Jordan where possibilities are believed to be favorable; 8, plateau of Trans-Jordan where possibilities are still little known. Compare Figure 2, p. 552. Scale of map 1 : 3,600,000.

THE NEGEB

The Negeb is a vast, arid region covering about 10,000 square kilometers, or two-fifths of the territory of Palestine. It is not easy to define its northern limit. In the mountains of Judea the Negeb may be said to begin south of the plateau of Hebron where there is an appreciable decline in the mean elevation; in the coastal plain a line from Ashkelon to 'Artuf (Har Tov), as determined by De Martonne's index of aridity (15), may be adopted (Fig. 3). Only the northwestern part of the Negeb—the southern part of the coastal plain and the basin of Beersheba, a transitional zone (altitude 300–400 meters) between the plain and the interior plateau—has been studied with any degree of precision. This northwestern region differs from the rest of the Negeb in relief and geology, being composed of Quaternary deposits—alluvium, sands, sandstones, loess—resting on Pliocene sands, clays, and conglomerates.[4] Its soils seem to be favorable for agriculture: an alluvial cover along the foot of the mountains;

[4] L. Picard and P. Solomonica: On the Geology of the Gaza-Beersheba District, Jerusalem, 1936.

FIG. 2—Map showing the regions of Jewish colonization in Palestine. Key: 1, regions of Jewish colonization; 2, the marshes of Huleh, which it is proposed to drain; 3, Jewish village; 4, Jewish town; 5, Arab town; 6, town of mixed Jewish and Arab population. Scale of map 1 : 2,100,000.

thin patches of loess broadening out about Beersheba toward the east and the southwest and reaching as far as six kilometers east of Khan Yunis. The rest of the plain is composed of light soils, sandy, easy to cultivate, broken only by narrow outcroppings of Kerkur sandstone. The British expert Sir John Hope Simpson expressed the opinion that there would be "an inexhaustible supply of cultivable land" about Beersheba if irrigation were possible.[5]

On these lands, where the mean index of aridity is everywhere below 15 and often falls to 10, where irregularity of rainfall is the rule, colonization obviously is possible only with irrigation. The rarity of springs makes the problem a question of subterranean water resources. The question can be answered affirmatively as regards the plain at least. As a result of their experience with borings south of Tel Aviv, Jewish engineers affirm that the best wells of this part of the coastal plain are found near the border of the Negeb. The Jewish colony of Beer Tuvya has four wells, ranging from 80 to 90 meters in depth, which yield 120 to 130 cubic meters of water an hour, with a temporary depression of the water table of only 4 meters.[6] The

[5] Sir John Hope Simpson: Palestine: Report on Immigration, Land Settlement and Development, *Cmd. 3686*, London, 1930, p. 20.

[6] In his "First Report on Agricultural Development and Land Settlement in Palestine" (Jerusalem, 1931, p. 22, in his "Reports on Agricultural Development . . . in Palestine," printed for the Palestine government by the Crown Agents for the Colonies, pp. 1–53) Lewis French says: "A recent

sinking of the wells of Ruhama, in the Negeb itself, seems to indicate the prolongation of a water-bearing layer to the south. The wells of Gaza have been famous from antiquity. Water has recently been found near the town in sand at a depth of 8 meters. One of the wells, 26 meters deep, gives 35 cubic meters an hour, lowering the water level by 7 meters. A cross section shows: from the surface to 6 meters, black clay; 6 to 13 meters, white sand (water level at 8 meters); 13 to 20 meters, yellow sand; 20 to 23 meters, clay and sand; 23 to 26 meters, black clay. Borings have also been made successfully at Khan Yunis. This section of the Negeb is a part of the great hydrological system of the littoral plain of Palestine. In the plain three principal aquifers may be recognized: the first, at a shallow depth in sand, gives 1 to 3 cubic meters an hour for a boring of 1 meter in the water-bearing layer; the second, in the Kerkur sandstone, deeper and much richer, gives 10 to 15 cubic meters an hour, sometimes as much as 45 cubic meters; the third, of varying abundance, lies in the calcareous strata. However, this classification may be oversimple: in fact, there may be numerous levels, as in the Wadi R'ir, southern Algeria.

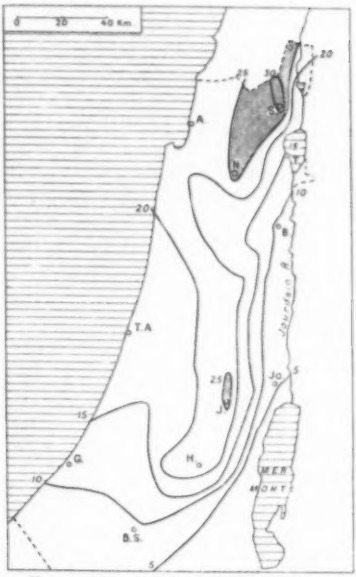

FIG. 3—Map of Palestine showing the index of aridity according to De Martonne's formula Ar = P/ T + 10 where P = mean annual precipitation in millimeters; T, mean annual temperature in °C. The map is reproduced on a reduced scale from J. Gottman: Une carte de l'aridité en Palestine. *Ann. de Géogr.*, Vol. 45, 1936, p. 431. Some of the stations shown on the original map have been omitted; those remaining, with the index of aridity, are: G., Gaza, 13; T. A., Tel Aviv, 19.4; A., Acre, 20.5; B. S., Beersheba, 6.5; J., Jerusalem, 25.6; N., Nazareth, 25.8; S., Safed, 31; T., Tiberias, 15; B., Beisan, 9.4; Jo., Jericho, 5.7.

Be this as it may, water is undoubtedly abundant in the subsoil of the plain along the shore and as far as 25 to 30 kilometers inland. However, the question remains open for the vicinity of Beersheba, whose name means "well of the oath." The wells of this region, which are mentioned in Genesis, range from 20 to 30 meters in depth

visitor to a part of California with conditions of climate similar to those of Palestine has described to me how large areas of land in the former country, which were once devoted to the production of various kinds of fruit, such as citrus and grapes, and to orchards, have been steadily thrown out of cultivation owing to the fall in the water-table having rendered all fruit-growing unprofitable." A particular case was described some time ago in the *Geographical Review* (H. F. Raup: Land Use and Water Supply Problems in Southern California: The Case of the Perris Valley, Vol. 22, 1932, pp. 270–278).—EDIT. NOTE.

Commenting on this, M. Gottmann remarks that decline is not progressive, and he points out that the geological structure of the two regions is very different and that wells in the parts of the Negeb he has studied have been functioning continuously for more than 3000 years.

and strike water at 12 meters in the chalk. Two government borings in the neighborhood proved failures: in one, water was not reached at 90 meters; in the other, which was sunk to a depth of 200 meters, only saline water was found. The latter result encourages the pessimists to imagine communication of the aquifer with the sea—a slender hypothesis, since between Beersheba and the shore there are layers of sweet water, even below sea level. It is more probable that the sweet water is in contact with a saline terrain. Such a case is seen in the boring at Giv'at 'Ada, south of Mt. Carmel, where the water crosses gray marls with a high salt content; some kilometers away the wells of Pardess Hanna and Kerkur furnish sweet water in abundance. In the Beersheba area also the chalk is interstratified with marls. It would be a mistake to despair of this region on the basis of only two borings; the intermittent stream of the Wadi Ghazza is rich in points of water. Farther south, in the heart of the Negeb, the well of Er Ruheibe, 130 meters deep, gives a good quantity of water. The Negeb remains a vast pasture ground for Bedouin camels because no attempt has been made to put it to other uses; wells are few, roughly built, and primitively equipped. Modern colonization would attack the problem with modern means. Water could be raised more than 50 meters if necessary. A reservoir on the heights of Hebron collecting the waters of various springs and wadies would furnish the Beersheba basin with appreciable quantities.

An advance post of Jewish pioneering, still modest enough, exists at Ruhama: this is a great collective farm abandoned by the colonists in the disorders of 1929 and reoccupied only in 1933. But since 1934 important Jewish purchases of land, amounting to some 18,000 acres, have been effected in the Gaza-Beersheba region. Settlers will soon be placed on these lands; what crops and methods of cultivation will be to their best advantage?

There has been considerable discussion of the agricultural aptitudes of the Negeb. There are advocates of cereal or industrial crops—sugar beets, cotton—which presuppose large-scale exploitation and a protective tariff, for they are expensive to raise under irrigation. It would seem better to leave such products to regions where irrigation is unnecessary or at least can be carried on by gravity. On the other hand, the Negeb could capitalize on the warmth of its climate and its proximity to ports by turning toward high-priced crops for exportation and for supplying the cities of the coastal plain, especially the rapidly growing ports. In the present condition of the world's markets it would hardly pay to extend the orange groves or banana plantations. But early vegetables and dairy products would find a ready market in the interior of the country; furthermore, the vegetables could be exported to Europe during part of the year, and the dairy products to various countries of the Orient.

Thus we envisage for the Negeb a varied polyculture by a popula-

tion of small farmers. Experts and commissions have attempted to define the *lot viable*—the minimum size of a holding that can support a family—for the given region. Now postwar experience in Palestine has proved that only by irrigation can a farmer be assured of an income enabling him to live on a European standard. The multiplication of small farms devoted to irrigated polyculture in the coastal plain has given surprising results that may well be applied to colonization of the south. An example taken from Gedera, between Jaffa and Ashkelon, may be cited: a farm of four acres, representing an investment of a capital of £1400, owned by a young couple with two small children. In 1935 the land was apportioned thus: 2½ acres under oranges, yielding more than 1000 cases of the fruit; an acre of vegetables, tomatoes from January to July, cauliflowers from July to December on half an acre and green peppers from July to October on the other half; half an acre of forage crops, supporting 5 cows, which gave an average of 4100 liters of milk each a year. A paid laborer was employed; the water for irrigation cost 1.5 cents (American) a cubic meter. In 1935 this farm yielded a net income of £480, which amply sufficed for a family of four (at Tel Aviv £120 a year is the average wages of a laborer).

A little farther north a two-acre farm with eight cows and an acre of strawberries yielded £270 net a year on an investment of £800. A four-acre farm growing early vegetables exclusively yielded a net income of £170 on an investment of £825. North of Acre the recently established village of Naharia, in exceptionally favorable circumstances, has obtained remarkable results on its very small farms. These examples could be multiplied: fruit, vegetables, forage crops, the raising of cattle for milk and meat, poultry permit varied combinations profitable for farms of less than 5 acres. In contrast with the great monocultural estates, orange plantations or others, they lend themselves perfectly to family cultivation, are more adaptable in times of crisis, and attach the cultivator more firmly to the soil. Colonization, of course, is an extremely complex matter: some succeed where others fail; and in the early stages it is experimental—many factors are unknown. But the examples before us are at least encouraging. Should the system succeed, some 4000 families of colonists can be settled on the lands already bought in the Negeb, and there still remain dozens of thousands of acres now uncultivated where irrigation is undoubtedly possible. If one wishes, one can see there the "revolution" in the population capacities of Palestine vaguely suspected by Sir John Hope Simpson; but turning to the east, to the Ghor, one sees still greater possibilities.

The Ghor

We understand by "El Ghor" the natural region formed by the vast tectonic depression running south from Mt. Hermon to the

Dead Sea. The political frontier, which follows the sinuous course of the Jordan, breaks the unity of the Ghor, separating Palestine and the Arab emirate of Trans-Jordan. In reality it is the Jordan that makes the unity of the region. Owing to its slope, the river is a reserve of energy; owing to the relative abundance of its waters, it is a source of fertility by irrigation. This is necessary, for south of Tiberias the index of aridity is not above 10.

North of the Ghor water is superabundant. At the foot of Mt. Hermon is the vast swamp of Huleh, which a Jewish organization is preparing to drain. The swamps merge into a shallow lake encompassed by numerous small springs.[7] Beyond Lake Huleh—or, as it is known in the Bible, Merom—the Jordan, sunk in a basaltic tableland, flows rapidly to the Lake of Tiberias. This lake has a surface area of 150 square kilometers; the Jordan pours into it an average of 30 cubic meters a second and leaves, impoverished by the intense evaporation, with a discharge of only 2 cubic meters a second at the end of September (low-water stage), though the average is 90 cubic meters a second during the spring floods. Some kilometers farther south the Jordan receives its chief affluent, the Yarmuk, which drains northern Trans-Jordan and a part of Hauran. Fed by rains, the Yarmuk carries only 6 cubic meters a second at low water but 1100 during the winter floods. The first hydroelectric power plant in the Levant, Tel-Or, has been erected at the confluence. The Jordan carries an average of 95 cubic meters a second into the Dead Sea and 75 cubic meters a second at low water; high water occurs not only in the winter, the rainy season, but in the spring and the beginning of summer, owing to the melting of the snows of Mt. Hermon.[8]

As a whole the Ghor would seem to lend itself easily to irrigation if the springs can be captured and the waters of the river raised to the cultivation terraces by the energy the river itself furnishes. Yet in no other part of Palestine, except the Negeb, is the country so desolate and desertic. Seen from the surrounding heights, the patches of verdure of Jericho, Beisan, and the Jewish farms south of Tiberias appear as typical oases. The causes of this desolation are wholly human. Before the World War the lands belonged to the Sultan, who had no interest in making them utilizable. The British authorities have limited their activity so far to the cutting of some kilometers of irrigation canals and to the establishment of two agricultural experiment stations; the great Arab proprietors have undertaken nothing of importance; the fellahin, conservative, ignorant, wretchedly poor, are incapable of contending with the forces of nature. But where men have attacked the problem with modern means, they have ob-

[7] See description by Roger Washbourn: The Percy Sladen Expedition to Lake Huleh, 1935. *Palestine Exploration Fund Quart. Statement*, Vol. 68, 1936, pp. 204–210.

[8] Figures of discharge furnished by the Head Office of the Palestine Electric Corporation, Haifa.

tained some splendid results, as a brief glance at three different cases will show.

Migdal is a small Jewish village perched on a hill above a tiny littoral plain on the Lake of Tiberias. At the foot of the dark basaltic wall overlooking the plain flows the spring of 'Ain Medawara, yielding 200 to 220 cubic meters an hour on the average (discharge reduced to half in the drought of 1933). An additional 240 cubic meters an hour is pumped from the lake to the most elevated lands, whence irrigation is carried on by gravity. On these lands, most of which belong to European capitalists, are grown bananas, citrus fruits, and early vegetables. The first receive 8000 to 10,000 cubic meters of water to the acre annually; the second 3000 to 4000. The vegetables (tomatoes, cucumbers, eggplant) yield two harvests a year and are sold through the great agricultural coöperative Tnuva for the home markets or Damascus.[9] The vegetables are often grown between rows of young orange or grapefruit trees not yet at the bearing stage. The citrus fruits ripen before those of the coastal plain; hence they are widely distributed at the beginning of the season and command a good price. All the plantations are exploited under one management, with marked advantage. The case of Migdal is interesting but rather special.

Deganya may serve as a type of large-scale collective farming. It is one of the most advanced eastern posts of Jewish colonization. Deganya,[10] "Corn of God," on the left bank of the Jordan, was founded in 1909. This *kvutza* (collective farm)[11] is one of the oldest colonization centers in the country. After the war it was divided into two, Deganya A and Deganya B, and today they are surrounded by a group of Jewish farms on both banks of the Jordan. Deganya B, the more recent, possesses 375 acres, of which 175 were irrigated at the beginning of 1934. The system is the most perfected in Palestine. A pumping station takes water from the Jordan, carries it under pressure through four conduits 250 meters long, to an elevation above the rest of the lands of Deganya B. Thence it is carried by an aqueduct of reinforced concrete 1100 meters long, with a capacity of 1500 cubic meters an hour, which bifurcates into a canal 4 kilometers long, carrying 1000 cubic meters an hour, and a smaller aqueduct, 250 meters long and extended 800 meters farther by canal. A network of irrigation ditches from these great arteries carries the water to fields and orchards. This water is very cheap, about £1 for 3000 cubic meters; hence there is a tendency to overirrigate.

[9] Information furnished by M. Iliov, director of the plantations of Migdal.

[10] Data gathered on the spot; figures by the secretariat of Deganya B.

[11] The merits of the collective system of farming have been much discussed. Believing that rural colonization can be firmly established only on a basis of individual property, we shall not argue the point; but in fairness it must be pointed out that the *kvutza* plays a useful part as a training school for colonists drawn from the cities of Europe and also gives an advantageous security on the desert border. But this is not the case with most of the collective farms of Palestine.

Up to 1934 the 200 unirrigated acres were devoted to cereals, but the great drought of 1933 ruined the harvest and forced the colonists to irrigate all the cultivable land. An experiment showed that irrigated wheat easily yielded 10 quintals to an acre as against the 5 to 6 quintals obtained by dry farming.

On the 175 irrigated acres is a remarkable variety of products. This was the distribution in 1933–1934: 45 acres were occupied by plantations, grapefruit (receiving 6000 cubic meters of water a year to an acre) on 30 acres and bananas (18,000 cubic meters, an obviously exaggerated amount) on 15 acres; 75 acres were occupied by lucerne (9 harvests a year) and clover; and 30 acres by garden vegetables, including tomatoes, eggplant, and cucumbers (each 2 harvests a year), carrots (3 harvests), and cabbages. This intensive agriculture demands large quantities of water and fertilizer, natural and chemical.

The important place accorded to forage crops in so arid a region (index of aridity 15 at Tiberias; 9.4 at Beisan) may seem surprising at first thought. But the raising of cattle is today the great resource of Deganya B. In 1923 the *kvutza* bought 12 head of cattle of Dutch and Damascene breeds; 10 years later the crossing of the breeds had produced 90 head, without any new acquisitions! The Ghor-bred cows give 4000 to 5000 liters of milk a year, which is sent by daily train to Haifa. Add to this a large poultry yard, and the diversity of Deganya B is seen. But the variety of possible cultures increases toward the south, in the degree that the Ghor deepens and the heat and aridity increase.

Jericho, at 250 meters below sea level, has a mean annual temperature of 23.3° C. (index of aridity 5.7), and to reach this little town one must cross solitudes so desolate that the expression "Go to Jericho" has a real significance! An islet of greenery in a red and yellow waste, Jericho owes its rich vegetation to irrigation from two springs. The 'Ain es Sultân, or Elisha's Fountain, the more celebrated of the two, forms a small basin at the foot of the hill of old Jericho; its discharge ranges from 600 to 700 cubic meters an hour. The other spring, 'Ain el Kelt, is interesting. It suddenly issues from a high and abrupt wall of Cenomanian limestone 12 kilometers west of Jericho, in the open Judean desert, whence one hears from afar the agreeable sound of running water. A small canal carefully cut in the rock carries the stream to the foot of the wall and leads it across the valley flank to Jericho. The Wadi el Kelt irrigates 375 acres of bananas, the property of a rich effendi, and it rarely happens that the water of this, the last tributary of the Jordan, actually reaches the main stream.

Almost all the lands of Jericho are crown lands. The state watches over the distribution of the waters of 'Ain es Sultân; the lands cultivated by the fellahin have been divided into 80 sections, each of which receives a watering every 20 days. The system assures a more eco-

nomical use of the water and permits the pools formed by the primitive Arab irrigation to dry up before the anopheles have time to develop. Some kilometers of cement canals have been constructed with the same purpose in view. The fellah cultivates cereals (wheat, barley, durra), which are harvested in April, and on the same fields in summer and autumn raises a variety of vegetables (in 1936 nearly nine-tenths of Palestine's vegetables were grown by the Arab peasantry); the effendi raises bananas besides; and the government, the greatest landed proprietor of the Ghor, has established an agricultural experiment station at Jericho for study of the best crops and regimes for the region and for improvement of Arab farming.[12]

It is a delight to find oneself under the thick canopy of verdure after traveling under the hot sun of the desert, and the variety of vegetation at the station there is no less agreeably surprising. Avocados and papayas are very much at home. The oranges are the sweet ones of Jericho, very different from the Shamouti of Jaffa; they receive 3200 to 4000 cubic meters of water an acre, bananas 10,000 cubic meters an acre. The banana also is at home here; yet according to the experience of the station the tree should be uprooted after eight or ten years because it exhausts the soil and yields no more good fruit. Similar observations have been made at Deganya. This means that the banana should be grown in crop rotation. The station has followed bananas with oranges; this practice, however, has the disadvantage of rendering the soil economically unproductive for six years.

But the orange and banana trees form only the median stage of the vegetation, the most thickset of the crops of the oasis. Above, the date palm raises its elegant silhouette. Jericho, the "City of Palms" of antiquity, now reports not more than 50 palms. The station has sought to add to the local varieties of Hayáni and Bint 'Aísheh more prolific strains, introduced from Egypt and Algeria. Since 1932 the station has also been studying the cultivation of early vegetables, to enrich the list known to the fellah. Some particularly interesting results have been obtained as regards the tomato and the potato; the potato has yielded 14 harvests a year at the rate of 8 tons to the acre.

To all these products such possible ones as cotton, rice, and sugar cane must be added, for the valley of the Jordan recalls in its climate the valley of the Nile. The agriculture of this region should, in fact, be highly flexible to the demands of the market. Jericho today is only a large village, cultivating some 2000 to 2500 acres. It is true that to the south and east the soil is infertile, but to the north the land is excellent and water is not lacking. Some few kilometers from Jericho the spring 'Ain ed Duk yields 600 cubic meters an hour; 10

[12] Data on Jericho from M. Rosenberg, director of the experiment station, and M. Deouell, district veterinary officer, who kindly supervised our visit to the oasis.

kilometers north of the town another spring, 'Ain el 'Auja, although sensitive to the variations of the rainfall, has a mean flow of 1500 cubic meters an hour; but these waters are unutilized. A Palestinian agricultural expert, M. Asaph Grasovsky, senior horticultural officer, estimates that on the right bank of the Jordan from Tiberias to Jericho nearly 65,000 acres, today sterile, are irrigable. Sir William Willcocks estimated the irrigable land in the Ghor at 92,000 acres. North of the lakes irrigation by gravity of the Huleh region would be easy. The fellahin could satisfy most of their needs therefrom, and outside their cultivated fields there would be room for a numerous population. Nature, in fact, has destined the Ghor to be a region of high population density, but up to the present time man has not profited by the intention. This is still truer of the left bank of the Jordan, the Ghor of Trans-Jordan, where there do not exist even the equivalents of the Arab agricultural centers of Beisan and Jericho.

The Plateaus of Trans-Jordan

Ascending the abrupt wall overlooking the Ghor on the east one reaches the high limestone plateaus, the northwestern border of the great Arabian shield. The average altitude is about 1000 meters; the mean annual index of aridity is below 20, often below 15, and declines rapidly toward the east and south. These plateaus, where today a settled life prevails only to the northwest have had a glorious past: the size and magnificence of the ruins bear witness to an advanced civilization both to the north (Philadelphia, now 'Amman) and to the south (Petra). It was much easier to go from Jerusalem to the port of Ezion-Geber in Solomon's time than it is to go from Jerusalem to 'Aqaba today. Toward the beginning of the Christian era Gilead and Moab and Edom had a comparatively dense and wealthy population, much larger than the present one: the testimony of numerous travelers concurs on this point. Major C. S. Jarvis, who knows the general desert border region well from long residence in Sinai, wrote recently of Trans-Jordan:[13] "Here is a country that once supported hundreds of thousands of cultivators now containing thousands only." He remarks on the size of the theaters and amphitheaters of Petra, 'Amman, and Jerash. What is the cause of the decline? Is it due to change in the climate?

We have no valid proof of such a contingency; on the contrary, the economy of Biblical times would seem to be adaptable with the present climate of the Holy Land. But formerly every thread of water was carefully used for irrigation; today large amounts are allowed to go to waste. By impounding the waters of the eastern tributaries of the Jordan and the Dead Sea before they leave the

[13] C. S. Jarvis: The Desert Beduin and His Future, *Journ. Royal Central Asian Soc.*, Vol. 23, 1936, pp. 585–593; reference on p. 589.

plateaus a minimum (summer flow) of some 20 cubic meters of water a second could be obtained. Springs located in the far interior have been vaguely reported. Cisterns could be built to retain the winter rains, and there are the subterranean resources, which will be referred to below. Truly the decadence of Trans-Jordan cannot be explained on physical grounds. The driving out of the sedentary population has been due to purely human causes, especially an advance of the nomads from Arabia, which has been made in several stages. This is what the prophet Isaiah says of Moab:

> For the waters of Nimrim shall be desolate: for the hay is withered away, the grass faileth, there is no green thing.
>
> Therefore the abundance they have gotten, and that which they have laid up, shall they carry away to the brook of the willows.
>
> Let mine outcasts dwell with thee, Moab; be thou a covert to them from the face of the spoiler.
>
> Isaiah xv, 6, 7; xvi, 4

If the settler would cross "the brook of the willows" again, the ruined cisterns must be rebuilt, the broken terraces restored, and the fields cleared of stones, as the colonists have done on the mountains of Judea. In other words, the mountain must be reclaimed. The calcareous soils and the basaltic ones of the northeast promise fertility. The springs of Yarmuk, Jabbok, Nimrin, and Arnon would permit the creation of a string of oases in echelon from north to south, west of the railroad from Damascus to Medina. In the waterless areas cereal cultivation with dry-farming methods and mechanical aids might be attempted: it would be more in place there than on the small fields of Emek. Thus little by little the desert could be made to blossom. How this would all work out it is impossible to say; there are too many complex human and physical factors involved: but a beginning might be made with the reclamation of some 15,000 to 20,000 square kilometers, and even this would be a long-time job.

Today Trans-Jordan, including the eastern Ghor, has a population of some 300,000 on an area of more than 40,000 square kilometers. The British government's mandatory report for 1936 to the League of Nations notes the progress in agriculture during the last decade. This progress has not been steady, for there have been dry years with terrible famines. In 1933-1934 the British army came to the aid of the population, threatened with decimation. Neighboring Palestine, prosperous and in full economic development, has not failed to offer a strong attraction for this poverty-stricken population. A continuous current of emigration has carried some thousands of Arabs west of the Jordan—the fellahin, be it understood, rather than the Bedouins. If this contrast persists, there will be a still greater setback to the country east of the Jordan. To reëstablish equilibrium, a flow from the west must recross "the brook of the willows."

The Obstacles

In the light of our reconnaissance, such appear to us the possibilities of the pioneer fringe of the Holy Land. We do not think that we have been unduly optimistic. In these first essays the desert has proved rather frightening to colonists used to more humid countries. Only people who know and appreciate the practice and advantages of irrigation can conceive of the colonization of desertic regions; and this cannot be learned in a decade. Furthermore, up to the present time opportunity has not been lacking in Palestine, where rural life is on an easier scale. It was only with the great influx of colonists in 1933–1935 and the rise in the price of land that attention was turned toward the empty spaces of the east. Moreover, entry into Trans-Jordan has been prohibited to the Jewish colonists by the British authorities, and the crown lands, which make up the larger part of the Ghor, have also been closed to them.

Besides these reasons there is another, which often plays a decisive part—the danger to which Isaiah pointed: the insecurity that reigns on the desert border and pushes back settlement. Since 1929 the local authorities have not been able regularly to assure even the security of the townspeople, and organization for self-defense is illegal; hence the risk is considerable. The Bedouin problem complicates the situation.

All these obstacles remain at the time that these lines are being written (February, 1937). Insecurity is greater than ever; but we trust that out of this crisis an effective protection of the colonists will issue and that agrarian measures will permit the realization of latent possibilities. We believe that on the margin of "Utilizable Palestine" there is in the aggregate a considerable area that can be cultivated with success and profit. Its extent depends everywhere, except in the Ghor, on the underground water resources. It is on this point perhaps that we most merit being reproached with optimism, and we shall now examine it broadly.

The Problem of Underground Water Supplies

Researches in the subsoil of Palestine reveal a vast extent of water-bearing layers. Borings have been numerous, and the results have been diverse, since these researches have been only experimental. To reduce the hit-or-miss character of the water-boring trials, the provenance of the water must be determined; then the underground circulation can be mapped. On this subject there exists a classic explanation, regularly appealed to by geologists, including Mr. G. S. Blake, geological adviser to the government of Palestine.[14] Rain water percolating through the limestone or basalt mountains and

[14] Geology and Water Resources of Palestine, Jerusalem, 1928.

plateaus descends by numerous joints and fissures to feed the phreatic layers. Mr. Blake has calculated that of the 1300 million cubic meters of rain water that falls yearly on Judea some 265 million cubic meters on the average cannot be accounted for by surface flow, evaporation, or the discharge of springs and therefore feeds the subterranean circulation. This clear and simple theory has also been adopted for Syria and Lebanon by L. Dubertret.[15]

But in Palestine the application of this theory to the water-supply problem has had misleading results. The geologists affirm that it is useless to sink wells in the basaltic plateaus of Galilee, west of the Lake of Tiberias, for the percolating water will rapidly regain the lake or the Jordan. To save the Jewish colonies of the region, the Pica (Palestine Jewish Colonization Association, founded by Baron Rothschild) sought to sink a well near the colony of Yavneel. Blake could find only one place in the neighborhood where at a great depth some five cubic meters of water an hour might be looked for; but this yield is so insignificant that it was decided to drill elsewhere. The boring effected under the direction of that great irrigation technician, I. S. Rosenfeld,[16] found water at a depth of 46 meters. Yavneel, it may be noted, is 100 meters above the Lake of Tiberias and more than 100 meters below sea level. The well, 86 meters deep, easily gives 350 cubic meters an hour, which lowers the water table only 4 meters, so that this is one of the most abundant wells of Palestine. The strata traversed by the well of Yavneel are: from the surface to 20 meters, black clay mixed with limestone pebbles; 20 to 39 meters, coarse basalt; 39 to 51 meters, layers of basalt with lime and clay in between (water table at 46 meters); 51 to 86 meters, porous basalt and rough basalt sand. This success was pronounced a miracle: the Holy Land is fertile in miracles! But M. Rosenfeld repeated it by drilling last year (1936) at Beit Gan, 2 kilometers from Yavneel, a well almost as abundant. Although the new well is above the older one, the water level is 10 meters lower, and chemical analysis shows water of an entirely different composition. The two wells, then, are not nourished from a single current of water descending from the heights to the lake but are at different levels, and their surprising richness indicates that their alimentation can hardly be local.

These observations suggest that the classic theory attributing the subterranean waters to rains falling in the region must be reconsidered; there are other objections. From 1930 to 1933 Palestine passed through a prolonged drought, four consecutive years whose effect on the surface circulation was very evident: many springs dried

[15] L'hydrologie et aperçu sur l'hydrographie de la Syrie et du Liban dans leurs relations avec la géologie, *Rev. de Géogr. Physique et de Géol. Dynamique*, Vol. 6, 1933, pp. 347–452.

[16] M. Rosenfeld has devoted fifteen years to the struggle for water in Palestine, where his high competence has been universally recognized. A good part of the unpublished documentation of this article is due to him, and acknowledgment is here made to his courtesy.

up, and the flow of others lessened appreciably; but the wells sunk to the aquifers remained stable. In a general way these levels are little sensitive to the caprices of the rainfall. Sometimes variations in certain wells are observed; often the level sinks some meters early in the year, to rise again in September before the beginning of the rainy season. This has been explained as a result of retardation due to slow percolation; but why, then, is the phenomenon not general instead of exceptional? And how explain the indifference of the subterranean water to the four-year drought?

The underground water is in active, although slow, circulation. The aquifer of the coastal plain is certainly in contact with the Mediterranean: sweet water has been found gushing out under the sea, particularly in the bay of Haifa. The water is plainly under pressure: in several wells it rises when the boring is made, even if the pressure is not great enough to create a flowing well. The drilling of very abundant wells at Wadi Hawarith, near the coast, where the sweet-water level is below that of the sea, confirms the idea that the layer of sweet water is under sufficient pressure to resist penetration by the salt water.

The abundance of artesian resources and their stability are against the idea of local origin; then whence comes the water? M. Rosenfeld does not hesitate to envisage the possibility of a distant origin, for he believes that the levels in western Palestine are insensitive to the pluvial regime of the Mediterranean. Rather must the source be looked for in a region of abundant rains whose irregularities are smoothed out by virtue of their distance. Such a region exists in the heights of Armenia, at the source of the Euphrates, and beyond, in the Caucasus. If such is the case, we can picture a vast underground circulation in all western Asia, a flow descending a thousand kilometers from these high massifs; but the concept is too vast for ready proof or disproof of its validity. The possibility of an underground flow coming from afar has been demonstrated in southern Algeria by J. Savornin; but the geological structure of western Asia, with its folding and its profound faulting, makes the problem more complex here. It would be temerity to attempt its solution, but the problem should be pointed out, for it has large consequences for the human geography of the Levant.

It is a little too early to speak with assurance of the subterranean water resources of Palestine;[17] but whatever the source of these waters, the indications at least permit us to be hopeful.

The Future

In conclusion, in our opinion the development of a broad front of colonization south and east of the Holy Land appears possible,

[17] Compare footnote 6.

even probable. There is human material at hand. Major Jarvis, discussing the possibilities of settlement in the Negeb and Trans-Jordan, does not know where to find the men. For the south he thinks of "the surplus cultivators from the existing villages such as El Arish, Khan Yunis, Gaza, Tafileh, Kerak, etc."[18] But one has never heard of a surplus of this kind. For the east he thinks to convert the Bedouin to the sedentary life—an interesting idea, no doubt, but one that would solve only a fraction of the problem. On the other hand, Jewish colonization is ready to advance to conquest of the desert. It is significant that this tendency is especially strong in the second generation of colonists, among the young people born or bred in Palestine. In November, 1933, we visited a small Jewish settlement in the Plain of Jezreel at the source of the Harod River, whose inhabitants had been recruited solely among the young people from the Jewish schools of Tel Aviv and Haifa. Nowhere have we seen more ardent pioneers. To the question "What do you expect to do?" we got the reply, "To go east; this is only a preparatory stage." The Palestinian Jews believe that Trans-Jordan, now closed, will eventually be opened to them; this is shown by the repeated attempts to acquire land and by the claims presented by the Zionist leaders to the Royal Commission. These claims are not only economic. The spiritual urge of the pioneer has been well described by André Siegfried:[19] "Many countries—and they are to be envied—possess in one direction or another a window which opens out on to the infinite—on to the potential future. . . . And to them it acquires a symbolical, almost a spiritual significance." For Jewish colonization this direction is east. The south is more easily accessible, nearer present centers; but the possibilities of the Negeb are limited after all. The east, on the other hand, is vast and opens broadly on the great deserts of Arabia.

The present situation recalls Biblical history: will it repeat itself? A new exodus would give this little country a political and economic refulgence, and it is in the same desert that the colonizers would recruit their forces before reaching their goal. Is not the Old Testament the history of the growth and decadence of a pioneer fringe?

[18] *Op. cit.*, p. 589.

[19] Canada, translated by H. H. Hemming and Doris Hemming, New York, 1937, pp. 31–32.

THE PROBLEM OF PALESTINE

A NOTE ON THE REPORT OF THE ROYAL COMMISSION*

PALESTINE, the "thrice-hallowed land," is a small state, a little smaller than Belgium, a little larger than Vermont; it has fewer than a million and a half people; its resources are meager: but the problem of Palestine is ancient and far-reaching.

> "Perhaps the most serious aspect of any disturbance in Palestine is the fact that the two communities chiefly concerned—the Jews and the Arabs—are not local entities, but form part of two groups with religious and racial affinities all over the world. Any trouble in Palestine, therefore, at once takes on international dimensions. It affects 15,000,000 Jews dispersed throughout most countries in the world; it is a matter of intimate concern to the new Arab States and to Egypt; it is a vital problem for Great Britain as Mandatory Power and for the whole British Commonwealth with its tradition of friendship to both communities and its Moslem population of 100,000,000. Further, Palestine, under whatever régime it is governed, is as important as Egypt from the point of view of British imperial communications. Strategically, it is the eastern outpost against any potential threat to the Suez Canal; it is the outlet of the oil pipe line from Mosul; it is a halting place on the international air route to India and beyond, and it is a starting point for the desert motor road to Asia."[1]

The present acute phase of the Palestinian problem began with the commitments made to Arabs and Jews during the war, commitments that have proved incapable of resolution, ever since the Mandatory began seeking to "discharge the contradictory obligations of the Mandate," until now that "the situation in Palestine has reached a deadlock." The very serious troubles in April, 1936, led to the appointment of the Royal Commission whose report, presented in July, 1937, has already become famous—or notorious—for its drastic proposal of partition.

The burden of the report, iterated and reiterated, is the impossibility of securing harmony between the two peoples under one government. The situation is paradoxical in the highest degree. "The removal of an Arab grievance creates a Jewish grievance and vice versa." The country was uniquely prosperous during the world-wide depression, but "with almost mathematical precision the betterment of the economic situation meant the deterioration of the political situation." A delegate sent by the Arab Executive to London in 1922 is quoted as saying: "Nature does not allow the creation of a spirit of co-operation between two peoples so different." The trouble lies not in racial or religious but in cultural differences.

> "Though the impact of the West is now profoundly influencing the Arab political scene, it has so far little affected the social structure of the Arab community; the economic structure it has only affected in parts.
>
> "The life led by the community is not unlike that of medieval Europe; it is a feudal organisation consisting of a small number of landowning families and a backward peasantry, partly nomadic (*bedawi*) and partly settled (*hadari*) and chiefly engaged in agriculture."[2]

The feudal aspects of the situation are in the main a legacy of Turkish rule. Into this essentially Oriental society has been introduced an alien Western culture.

*Palestine Royal Commission Report, *Cmd. 5479*, London, 1937.

In this note quotations without stated source (but with page reference in parentheses) are from the Report.

[1] Great Britain and Palestine 1915-1936. *Royal Inst. of Internatl. Affairs Information Dept. Papers No. 20*, London, 1937, p. 9.

[2] *Ibid.*, p. 31.

The Jewish National Home provided for by the Mandate is developing as "a highly educated, highly democratic, very politically minded" community, which by 1936 had "practically grown into something like a State within a State. The Jewish community in Palestine now numbers 400,000 persons, with its capital, Tel Aviv, the largest town in Palestine, its national flag, its anthem, its cultural system, its network of social services" (pp. 305–306).

The Land Question

As for specific matters, the two vexed questions, "stumbling blocks from the start," are land and immigration. By Article 11 of the Mandate the Mandatory undertakes to "introduce a land system appropriate to the needs of the country, having regard, among other things, to the desirability of promoting the close settlement and intensive cultivation of the land." Article 6 states that "the Administration of Palestine, while ensuring that the rights and position of other sections of the population are not prejudiced, shall facilitate Jewish immigration under suitable conditions and shall encourage, in co-operation with the Jewish agency referred to in Article 4, close settlement by Jews on the land, including State lands and waste lands not required for public purposes."

Unfortunately the extent of land available for settlement is not known, in terms either of ownership or of suitability for cultivation. The government does not know precisely how much land it owns as State Domain or as waste. Although some improvements have been introduced, the complicated Ottoman Land Code, with all the difficulties involved in its various forms of ownership and tenure, is still in operation; and it is no easy task to formulate a new code that "can absorb the existing system and adequately meet the needs of the Bedouin population on the one hand and an advanced urban and rural population on the other" (p. 227). Nor has the situation been "rendered any easier by the unavoidable pressure of the Jews for land purchase and consequent land speculation."

"Remembering, then, that the settlement operations in five-sixths of the country may materially alter the present estimates as to ownership of land, it is now necessary to discuss the much debated problem as to how much of the land in Palestine is cultivable, and how production can be increased" (p. 233). Palestine is a land of great physical contrasts—the bleak hills of Judea set off against the hot lands of the Ghor, below sea level; swamplands, fertile when drained, against desert lands, fertile when irrigated. Each region has its own problems. Excluding the arid subdistrict of Beersheba, which must be considered apart, the government's estimate of the cultivable area is 7,120,000 dunums (a dunum = 0.227 acre), a little more than half the total area. Jewish estimates are apt to be considerably higher. In the opinion of the Commission:

> "We ourselves do not consider it possible at any given date to estimate with any accuracy how much land can be classed as 'cultivable.' This must depend, as is generally recognized, on irrigation and the improved use of available water supplies, on the draining of marshy areas, and on the adoption of new methods of agriculture, more especially in the hills. These last in turn depend on the amount of capital available. The Arab peasant has at present neither the capital nor the education necessary for intensive cultivation. The Jew has. But the lack of these two essential requisites does not justify the expropriation of the Arab to make room for the richer and more enterprising colonist, even though the Arab's conservative methods, and in some cases his system of land tenure, may delay development" (p. 235).

In estimating present or potential cultivability water supply is a prime factor. Water in Palestine is derived mainly from wells and springs. Another unsatisfactory legacy from Ottoman law makes the water in springs individual property. To

ensure more economical use of such water, the Commission recommends the vesting of the rights in government, pointing out that legislation of this kind has proved necessary in all countries where irrigation is important. It also recommends that some control over the sinking or deepening of wells—the main source of supply—should be anticipated if there is any sign of lowering of the water table, though there is no apparent decline at present. As regards the one important river of the country, the Jordan, there is the possibility of conflicting interests between future irrigation and the Palestine Electric Corporation's concession.

Immigration

According to the Mandate the doors of Palestine are open to Jewish immigration to the extent of the "economic absorptive capacity" of the country, a criterion elastic and susceptible of varied interpretation. The recent great wave of immigration has been accompanied by prosperity; immigration has increased economic absorptive capacity for the time being. Is this sound? Will it last? All the circumstances of Jewish immigration into Palestine are peculiar.

> "The colonies of the New World were mostly founded by settlers of a single nation, drawn mainly from the working or lower middle class and not of very varied occupations. The Jewish immigrants came from a variety of different countries, and represented all classes and activities. Their settlement resembled that colonization by a complete society in miniature—a slice through all its strata—which the Colonial Reformers in England in the early nineteenth century dreamed of but never realized. It was unique, too, in the preparations made for it. Not only had most of the immigrants been carefully selected by the Zionist Organisation, but a number of them had undergone a three-years' course of training, mostly for agriculture but also for industry and handicrafts, in twenty centres established in various European countries" (pp. 46–47).

From 1933 to 1936 inclusive, 17,653 persons possessing a capital of at least £1000, representing 11 per cent of the total Jewish immigration, entered the country.

> "The most singular feature in the economy of Palestine is the vast amount of capital which has been invested in the country, for which no remittances abroad for interest and sinking fund are required. This feature sharply differentiates the Jewish National Home from other communities which have been created by a process of colonization and are burdened by charges on the capital obtained from overseas for their development. The dangerous position of Jews in Europe and the enthusiasm for settlement in Palestine have brought a plentiful supply of capital, which has been invested in the country. Apart from the £63,000,000 invested by private enterprise, some £14,037,000 subscribed by Jews in their national funds has been devoted to the draining of swamps and the reclamation of land, the training of immigrants and industrial experiment" (p. 212).

But even if this is a stable and permanent state of affairs, the question may be raised whether all sections of the population have been benefited—the Arab as well as the Jew. The Commission's conclusion is that materially the balance is on the credit side. But there is also the psychological factor. Jewish immigration has proved an economic stimulus; but, in the words of an Arab spokesman, "Who that wants salt empties the whole cellar into his plate?" The Arab has been thoroughly alarmed. The Commission's report foresees a "reduction in the standard of living" (pp. 212–213) when the exceptional advantages (of inflowing capital, etc.) are withdrawn; which means, among other things, will this not force the Jews to press upon land now under Arab control or bear the increased cost of town-made industrial products turned out mainly by Jewish concerns?

The average Jewish immigration for the period 1933 to 1936 inclusive has been

at the rate of more than 40,000 persons a year, exclusive of the unknown but large illegal entry. The Jewish population has nearly doubled in these four years; it is now (1936) estimated at about 370,483 (again exclusive of illegal immigrants), in a total population of 1,336,518. The increase of the Arab population has been at a relatively high rate—owing to the cessation of conscription and improvements in health and sanitation—but this is mainly natural increase. If trends remain as they are, with an annual Jewish immigration of 40,000, the two populations will be equal in 1954. The haste of Jewish settlement is indeed at the root of much of the trouble. As a sympathetic observer puts it:

> "Its [Palestine's] economic development will necessarily be slow—inevitably too slow to satisfy either the *perfervidum ingenium* of the minority of its inhabitants, or the sympathies of those of us outside Palestine who would be glad to see the country absorbing larger numbers for whom many parts of Europe have become prisons of cruelty and humiliation. A country of its size and character cannot support a sudden and unlimited influx of new inhabitants; the urgency of the external Jewish problem merely accentuates the necessity for controlling immigration."[3]

Arab Nationalism

The fear caused by the rate of growth of the Jewish National Home and the growing desire of the Arabs for independence have been interacting. There is a certain artificiality to the boundaries of the new states carved out of the old Ottoman Empire.[4] Arab nationalism in Palestine is exposed to the pressure of events in her neighbors, in all of which notable advances towards self-government have been made of late. 'Iraq obtained her independence in 1932. In August, 1936, the Anglo-Egyptian Treaty of Alliance made Egypt a sovereign, independent state. In September, 1936, the Franco-Syrian Treaty of Alliance was signed whereby within three years France is to resign the Mandate and support the application of Syria for admission to the League of Nations with full national status. In November, 1936, a similar treaty was signed between France and Lebanon. As the director of the French Institute at Damascus put it: "The Arab world has developed all around us much faster than we should have wished."[5]

Thus arises the paradoxical situation that the Arabs of Palestine are as fit to govern themselves as the Arabs of 'Iraq or Syria, the Jews as fit as any organized and educated community of Europe or elsewhere; yet, associated as they are under the Mandate, self-government is impracticable for both.

The Plan of Partition

The Commission concludes that under the force of circumstances the difficulties of partition do not seem so insuperable as the difficulties inherent in continuation of the Mandate or any alternative plans that have been proposed. "Cantonisation," it is considered, would not settle the question of national self-government, and for a federation of separate units to succeed they must be bound by common interests. The division of Syria "into five different States with five different governments, five different administrations, five different budgets, and five different constitutions" is considered by one observer to have been "one of the main sources of unrest and discontent" in Syria.[6]

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[3] Sir Andrew McFadyean: Immigration and Labor in Palestine, *Foreign Affairs*, Vol. 12, 1933–1934, pp. 682–688; reference on p. 683.

[4] E. W. Polson Newman: Middle East Mandates, *Contemporary Rev.*, Vol. 136, 1929, pp. 705–711; also George Antonius: Syria and the French Mandate, *Internatl. Affairs*, Vol. 13, 1934, pp. 523–539.

[5] Robert Montagne: French Policy in North Africa and in Syria, *Internatl. Affairs*, Vol. 16, 1937, pp. 263–279; reference on p. 272.

[6] Antonius, *op. cit.*, p. 526.

FIG. 1—Sketch map of Palestine and neighboring states. Scale 1 : 13,000,000. The plan of partition for Palestine proposed by the Royal Commission is shown by shading: The ruled area is the territory to be united with Trans-Jordan to form the Arab State; the stippled area is the Jewish State; the solid black, the territory of the new Mandate. (For larger-scale maps of Palestine see pp. 551 and 552.) This map is mainly based on Plate 7 in the Commission's report. Other maps in the report, on a scale of 1 : 1,000,000, show progress of survey and land settlement, Jewish-owned land, State Domain and forest reserves, cultivation zones (distinction between plains and hills and between areas with more than and less than 10 per cent under cultivation), and administrative boundaries.

The plan of partition proposed would create two sovereign, independent states, the principle of division being the separation of areas in which Jews have acquired land from those which are wholly or mainly occupied by Arabs.

"The Jewish lands and colonies are mostly to be found in the Maritime Plain between Al Majdal and Mount Carmel, in the neighbourhood of Haifa, in the Plain of Esdraelon and the Valley of Jezreel, and in the east of Galilee, i.e., south of Tiberias, on the shores of the Lake, near Safad, and in the Huleh Basin. The rest of Galilee and the northern part of the plain of Acre are almost wholly in Arab occupation. So also is the central hill-country of old Samaria and Judaea—except for Jerusalem and its vicinity. The towns of Nablus, Jenin and Tulkarm, the last an outpost on the edge of the Maritime Plain, are centres of Arab nationalism. Except in and near Jerusalem and at Hebron, there are practically no

Jews between Jenin and Beersheba. This Arab block extends eastwards to the River Jordan between the Dead Sea and Beisan. In the area stretching south and south-east of Beersheba to the Egyptian frontier, the Jews have bought some isolated blocks of land but the population is entirely Arab" (pp. 382–383).

A new mandate would be framed to care for the Holy Places, "a sacred trust of civilization." It would form an enclave including Jerusalem and Bethlehem, with a corridor by way of Lydda and Ramle to the sea at Jaffa. It is also proposed that the four "mixed" towns Tiberias, Safad, Haifa, and Acre should be kept for a time under Mandatory administration. It would, of course, be impossible to draw a frontier separating all Arabs and Arab-owned land from all Jews and Jewish-owned land. An exchange of populations is proposed following the precedent of the exchange of populations between Greece and Turkey.[7] The chief difficulty would be placement of the Arabs to be moved. The poor hill country holds little promise for colonization. On the other hand, the Beersheba Sub-District and the Ghor would be in Arab hands, and, as M. Gottmann's article[8] informs us, the possibilities of these regions are worth exploring.

Arab Colonization

In southern Palestine, the Ghor, and Trans-Jordan the great problem is the problem of water. Referring to the present status in Beersheba the Commission observes:

"The Beersheba question is a very difficult problem, which has not been fully examined and in regard to which we would, in view of the experience of the land settlement of the comparatively small area of Beisan, strongly deprecate haste. It appears to us that the first steps to be taken are to ascertain the attitude and desires of the Sheikhs of the various tribes, the rights enjoyed by the tribes, and their attitude towards changing a nomad life for one of settled cultivation. Haste has been a potent factor in creating the troubles in Palestine, and no useful purpose would be served by introducing Jewish immigrants into the Beersheba area until the Government were assured that they would be amicably received. In the meantime, we can see no objection to the Government or to the Jewish Agency exploring the possibilities of a fresh water supply in any part of that country" (p. 247).

There are difficulties in the way of settling Arab peasants on new lands.

"First, there is the deeply-rooted aversion which all Arab peasants have shown in the past to leaving the lands which they have cultivated for many generations. They would, it is believed, strongly object to a compulsory transfer, even from one part to another of the comparatively limited area envisaged in a scheme of this kind.

"Secondly, the Arab cultivator finds it extremely difficult to change his methods of agriculture: to adapt himself to cultivation by irrigation. Even with the scientific example of his Jewish neighbours he would be unable to bring the land to its full productivity within many years. The change from dry farming and limited animal husbandry to intensive irrigation entails a complete change of the cultivator's habits, chief among which stands the fact that he would have to work all the year round, and that his farm would require daily attention instead of the leisurely annual disposal of cereal crops from dry farming" (p. 248).

Still more difficult is the question of settling the nomad Arab. Is the problem as hopeless as seems generally to be thought? Ibn Saud's experiment may be informa-

[7] Raoul Blanchard: The Exchange of Populations between Greece and Turkey, *Geogr. Rev.*, Vol. 15, 1925, pp. 449–456.

[8] See preceding article in this number of the *Geographical Review*, pp. 550–565.

tive. He "introduced the most important reform ever undertaken in the desert: the settling of the nomad Arabs around the wells of the desert. . . . The settled colonies were founded around wells and springs, the soil was irrigated, the elements of agriculture taught . . . The very foundations of nomad Arab society were radically transformed."[9]

Major C. S. Jarvis, who has had experience with the Bedouins of Sinai and southern Palestine, finds the problem of introducing them to cultivation "a most disappointing and almost heart-breaking work." Yet it is "not an altogether hopeless task."

> ". . . in the Wadi Gedeirat, where I had the advantage of running water and a Roman system of irrigation that only required reconstructing, I have definitely succeeded in settling some hundred nomads of the Teaha tribe on the land. They now have large orchards bearing a big variety of fruit; they sell their olives for a substantial sum, and in the summer, instead of moving off to Palestine for grazing as they did formerly, they remain on the land and grow millet, maize, and vegetables. . . . This is satisfactory proof that the Beduin can be settled on the land after a time if conditions are favourable. A simpler method of making use of the possibilities of the desert is to transport to the best lands the surplus cultivators from the existing villages such as El Arish, Khan Yunis, Gaza, Tafileh, Kerak, etc., but there is a difficulty here for every feddan of land in the desert is claimed by some Arab and he is most jealous about it."[10]

And again:

> "My contention is that something could be made of this area of Eastern Sinai, Southern Palestine and Western Trans-Jordan that has been allowed to go to waste. Mind, I am not suggesting that it can be made into a land flowing with milk and honey, or that it will provide a solution to the Jew-Arab question of Palestine.. It is not a country to which the man with an agricultural certificate should go expecting to earn good dividends, but it is a country that will support primitive man, provided he does not mind hard work and a bare existence. It is very suited to the hardy village folk one sees in Southern Palestine, Trans-Jordan, and Sinai. They would certainly make something out of it, but as I have already said they feel there must be some guarantee of protection from the Arabs if they settle there. It is going to be very uphill work settling the Beduin, but this should be attempted also. It is a harsh land with water shortage, sandstorms and every form of set-back; but it is an area that in the past undoubtedly supported at least 100,000 people, but today I doubt whether there are 2000 people living there."[11]

Trans-Jordan

As regards Trans-Jordan, the Commission's report may be quoted:

> "The country has not been fully surveyed, and there is not sufficient expert evidence available to form an estimate of the amount of uncultivated land which might be rendered cultivable. Opinions on the point tend to vary with political prepossessions. . . . It is clearly desirable that this uncertainty should be as far as possible removed, and we recommend that, as soon as the financial position permits, a survey of Trans-Jordan should be made and a scheme prepared for its irrigation and development.

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[9] Hans Kohn: The Unification of Arabia, *Foreign Affairs*, Vol. 13, 1934–1935, pp. 91–103; reference on p. 94.

[10] C. S. Jarvis: The Desert Beduin and His Future, *Journ. Royal Central Asian Soc.*, Vol. 23, 1936, pp. 585–593; reference on pp. 588–589.

[11] C. S. Jarvis: The Desert Yesterday and Today, *Palestine Exploration Quart.*, Vol. 69, 1937, pp. 116–125; reference on pp. 124–125.

"Meantime we are not in a position to fix even an approximate figure for the possibilities of new settlement in Trans-Jordan: but, in view of the evidence given by some of those who are acquainted with the country and from what we saw, we consider the hope to be justified that, if fully developed, it could hold a much larger population than it does at present. . . .

"The process of development, however, is bound to be expensive; and the cost could not possibly be met from the exiguous revenues of the Trans-Jordan Government or even from those of the Palestine Government. Assistance would have to be provided on a large scale by the British Treasury. . . .

"The development of Trans-Jordan can only help to solve the problem under the Mandate if it opens the way to a substantial amount of Jewish immigration, but . . . Arab antagonism to Jewish immigration is at least as bitter in Trans-Jordan as it is in Palestine. . . .

"The possibility of enlarging the National Home by Jewish immigration into Trans-Jordan rests on the old assumption of concord between Jews and Arabs. . . . As long as Jews and Arabs quarrel in Palestine they are unlikely to agree elsewhere; and in Trans-Jordan as in other independent Arab States the door will only be opened to Jewish enterprise in so far as friendlier relations are established in Palestine" (pp. 308–309).

Conclusion

The Royal Commission presents its recommendations for partition in brief and the difficulties in the way of application are not analyzed or envisaged, except as they are reflected in such suggestions as that for the exchange of populations and the provisions for interstate and British subventions to the Arab state.

Inevitably the proposal of partition has raised a storm of protest, not only among Jews and Arabs in and outside Palestine but among other interested peoples. France, for instance, is apprehensive. As a Frenchman addressing the Royal Institute of International Affairs said apropos of French and British interests in the Near East and North Africa: "Everything that touches us, touches you, and conversely. . . . The powder, once fired, spreads from one State to another."[12]

Only a part of the Commission's report has been touched on in this note; no mention, for instance, has been made of the important issue of education, a potent factor in the development of nationalism: but enough, perhaps, has been said to show the exceptionally interesting nature of the report as an essay in political geography.

[12] Montagne, *op. cit.*, p. 273.

SOME GEOGRAPHICAL RESULTS OF THE SECOND BYRD ANTARCTIC EXPEDITION, 1933-1935

I

THE SUBMARINE TOPOGRAPHY OF THE ROSS SEA AND ADJACENT WATERS*

S. Edward Roos

THE oceanographic program of the Second Byrd Antarctic Expedition, which left Boston in the latter part of September, 1933, included a systematic bathymetric survey in the form of echo soundings begun as soon as the Pacific Ocean was entered.

Soundings were taken hourly, i.e. about seven miles apart. However, when any outstanding change in the bottom configuration was encountered, or when a continental or insular shelf was approached and left, the soundings were increased to any number required to obtain the detailed profile of the bottom. In all, ten series, totaling 2723 soundings, were carried out by the *Bear of Oakland* during her various cruises.[1] They are: Panama to Tahiti; Tahiti to New Zealand (North Island); Dunedin, N. Z., to the Bay of Whales, Ross Sea; an exploratory cruise to the waters northeast of King Edward VII Land; a cruise across the Ross Sea to latitude 72° S. for a rendezvous with the R.R.S. *Discovery II*; Bay of Whales to Dunedin, N. Z.; Dunedin, N. Z., to the Bay of Whales (including the Scott Island Rise, western sector of the Ross Sea, and front of the Ross Shelf Ice); Discovery Inlet, Ross Sea, to Dunedin, N. Z.; Dunedin, N. Z., to Easter Island; Easter Island to the Gulf of Panama.

The soundings fall into two main divisions: the trans-Pacific series and the series related directly to the Antarctic. The present paper deals chiefly with the latter;[2] for the former see Appendix II.

The Sections: South of New Zealand

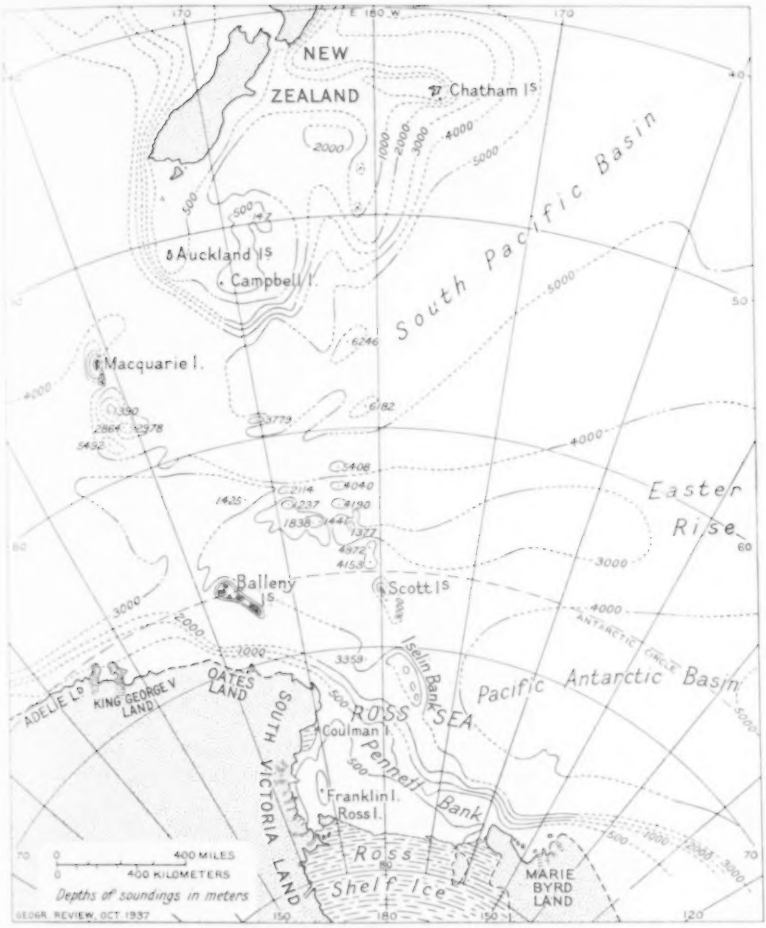
In general, the bottom contours crossed by the *Bear* on her four passages between New Zealand and the Ross Sea have an east-west trend. The most conspicuous feature of the sections is the pronounced

*Constituting *Contribution No. 91* of the Woods Hole Oceanographic Institution.

The writer wishes to express his gratitude to Mr. C. O'D. Iselin 2nd, counselor and guide in the preparation of the sounding data. All positions were determined by Lieutenant R. A. J. English, U.S.N., commanding the *Bear of Oakland*, for whose invaluable assistance the writer is greatly indebted.

[1] Photostats of the tabulated soundings have been distributed to the various hydrographic agencies. Additional copies can be obtained by request from the Woods Hole Oceanographic Institution, Woods Hole, Mass.

[2] A line of echo soundings between Dunedin, N. Z., and the Bay of Whales was obtained on the First Byrd Antarctic Expedition. These soundings are plotted, uncorrected, on the map of the routes of the *City of New York*, Plate II in W. L. G. Joerg: The Work of the Byrd Antarctic Expedition 1928–1930, Amer. Geogr. Soc., 1930.



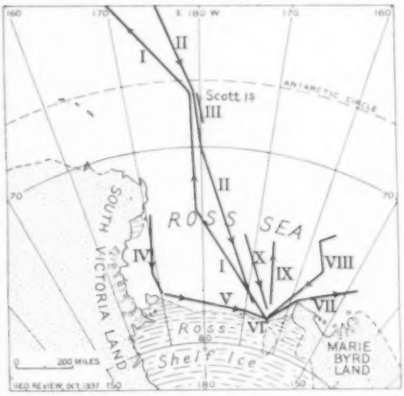


FIG. 1 (above)—Bathymetric map of the Ross Sea and adjacent waters; scale approximately 1 : 35,000,000. The map revises that part of the American Geographical Society's Bathymetric Map of the Antarctic (1 : 20,000,000), 1929. In addition to the soundings obtained by the *Bear* use has been made of the echo soundings by S. Y. *Discovery*, B. A. N. Z. Antarctic Expedition (Mawson), 1929, 1930, 1931, in "List of Oceanic Depths Received at the Admiralty during the Year 1932," *Publication H. D. 308*, London, 1933; soundings by R. R. S. *William Scoresby*, 1928, in *Discovery Reports*, Vol. 3, pp. 1–134 (Ross Sea soundings, pp. 124–131), 1930; soundings by R. R. S. *Discovery II*, 1932, in "List of Oceanic Depths . . . 1932"; soundings by *Thorshavn*, 1933–1934, list sent by H. E. Hansen, Norges Geografiske Opmåling.

FIG. 2 (right)—Index map to the profiles in the Ross Sea and neighboring waters. Scale 1 : 40,000,000.

ridge with its crest in 64° S. It is, in fact, a westward extension of the Easter Rise and separates the South Pacific Basin from the Pacific Antarctic Basin. The soundings from two of the sections are plotted in Figure 3.

The profiles (Fig. 3) show the New Zealand insular shelf receding

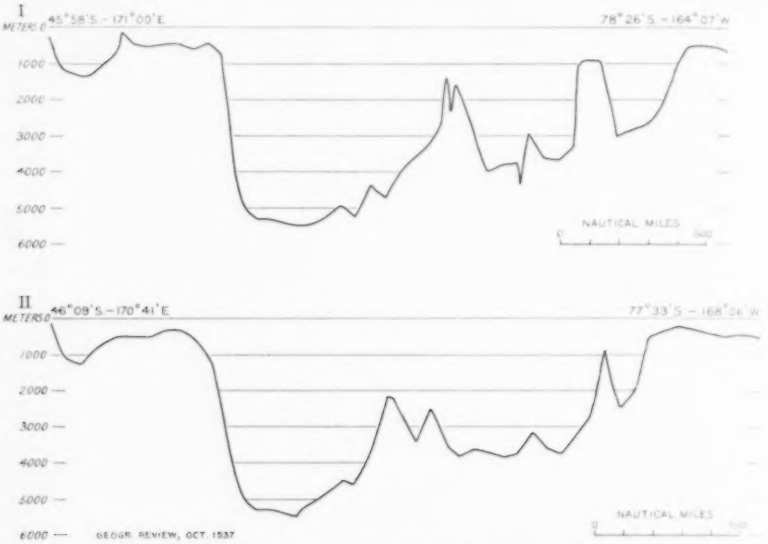


FIG. 3—Profiles I and II, New Zealand–Bay of Whales.

in a very steep slope to 5000 meters about 500 miles[3] south of the starting point, Dunedin. The trend of this contour on the chart (Fig. 1) indicates that the South Pacific Basin extends far to the southwest, possibly terminating at Macquarie Island. The maximum depth of water found by the *Bear* when crossing this deep tongue was 5500 meters; the bottom remained deeper than 5000 meters for a distance of 300 miles, until, at first gradually and then with greater incline, it shoaled to form the extensive rise mentioned above, the crest of which shows an elongated depression. The soundings indicate that the ridge deepens rapidly eastward. For the next 300 miles southward the depths again increase, except in the vicinity of Scott Island.

SCOTT ISLAND AND VICINITY

Scott Island, 67° 24′ S., 179° 55′ W., was discovered on Christmas Day, 1902, by the relief ship *Morning*, Captain Colbeck, of Scott's National Antarctic Expedition.[4] As Figure 1 suggests, this island

[3] All miles are nautical.

[4] G. S. Doorly: The Voyages of the 'Morning,' New York, 1916, pp. 58–62.

might well be called the boundary stone between the South Pacific and the Ross Sea.

Figure 4 shows the profile obtained on the second cruise of the *Bear*, season 1934–1935. The bottom rises steeply from a depth of 3800 meters for a distance of 12 miles to emerge as a rocky island about 175 feet in height, with precipitous sides, crowned with the characteristic Antarctic icecap, which extends seaward in a southeasterly direction. This shelf-ice formation was not apparent when the island was sighted—the second time since its discovery—by the First Byrd Antarctic Expedition in December, 1928.

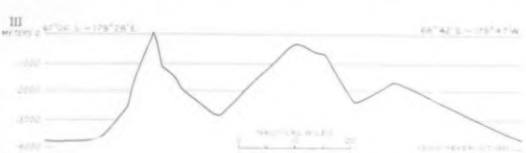


FIG. 4—Profile III, Scott Island, based on 35 soundings.

The near-by jagged peak of Haggitt's Pillar is really a part of Scott Island. Just south of Scott Island the bottom recedes steeply to 2900 meters, then rises again to 300 meters within 25 miles of the island. One may believe that this peak culminates in rocks awash. However, no breakers were observed from the deck of the *Bear*.

THE ISELIN AND PENNELL BANKS

About 200 miles south of Scott Island the *Bear's* soundings disclosed a heretofore unknown ridge, at a minimum depth of 700 meters, separated by a deep gully from the Antarctic continental shelf (see Fig. 3), which here rises with a steep gradient from a depth of 2800 meters. The discovery of this ridge, which has been named the Iselin Bank after Mr. C. O'D. Iselin 2nd of the Woods Hole Oceanographic Institution, is of interest in relation to the hypothesis of a structural connection between New Zealand and West Antarctica, comparable to the Scotia Arc postulated as a link of the Antarctandes.[5] The axis might run from the Alexandra Mountains by way of the Pennell Bank,[6] the Iselin Bank, Scott Island, and Macquarie Island to the New Zealand shelf. There are deep water gaps between these links, as there are between links of the Scotia Arc, but this objection is not insuperable. However, many more soundings are needed before any definite conclusions can be drawn.

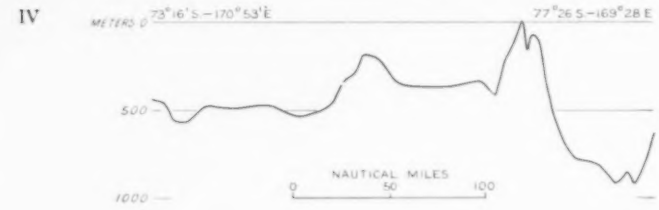
The Pennell Bank extends southeast to northwest across the Ross Sea. The suggestion of Griffith Taylor that the bank represents a vast terminal moraine[7], a remnant from the maximum glaciation, has

[5] For a discussion of the problem of the Scotia Arc see H. F. P. Herdman: Report on Soundings Taken during the Discovery Investigations, 1926–1932, *Discovery Reports*, issued by the Discovery Committee, Colonial Office, London, Vol. 6, pp. 205–236, Cambridge, 1932.

[6] An alternative course would be from the Pennell Bank via the Balleny Islands.

[7] Griffith Taylor: Antarctic Adventure and Research, New York and London, 1930, p. 160.

been further strengthened by the results of the dredging carried out from the *Bear*. After all the hauls the dredges were recovered filled with rocky bits of glacial debris. They were chiefly acid igneous rocks, though there were occasional fragments of the more basic varieties; sedimentary rocks were represented by small quantities of



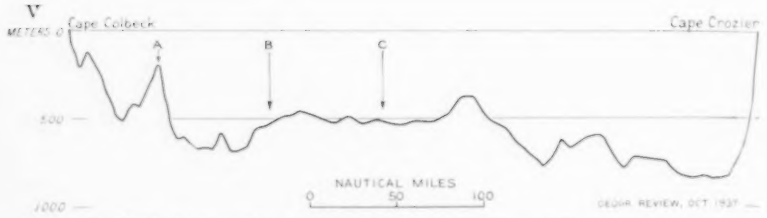


FIG. 5—Profile IV, Coulman Island to Ross Island, based on 57 soundings.

FIG. 6—Profile V, along the front of the Ross Shelf Ice, based on 151 soundings. A, eastern junction of the Shelf Ice; B, Bay of Whales; C, Discovery Inlet.

green shale and friable sandstone. When the *Bear* was leaving the Ross Sea in 1935, a shallow with a minimum depth of 134 meters was observed on the Pennell Bank in 74° 11′ S., 179° 43′ E. A bottom sampler was lowered at this point, where the bank tends to turn northward; however, the corer was recovered dented, an indication that it had struck a hard or rocky surface.[8]

WESTERN SECTOR OF THE ROSS SEA AND THE SHELF ICE

The profile reveals an irregular submarine topography in the western sector of the Ross Sea (Fig. 5). In the southwest is a depression bordered on the north by the Pennell Bank and interrupted by Franklin Island, a small volcanic island. Although separated from them by a gully with a depth of 900 meters, this island is structurally related to Ross Island, to the south, and Coulman Island, to the north.

Figure 6 is a profile parallel to the face of the Ross Shelf Ice from Cape Crozier, on Ross Island, to Cape Colbeck, King Edward VII Land. The slopes of Ross Island recede steeply to 850 meters; and

[8] See also the note on "Bottom Deposits of the Ross Sea" elsewhere in this number of the *Geographical Review*.

for a distance of 150 miles eastward the bottom remains at a depth of about 600 to 750 meters—an indication that the depression continues under the shelf ice. Farther to the east the bottom rises markedly to the lowest recorded depth of 352 meters. The profile shows another drop, to about 700 meters, at the Bay of Whales (Fig. 6), where an arm of deeper water penetrates into the Pennell Bank.

The probability that the Ross Shelf Ice is resting on the bottom at any point along its front seems remote, though evidence seems to

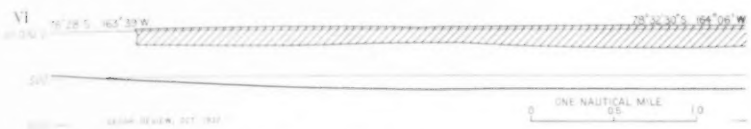


FIG. 7—Profile VI, the floor of the Bay of Whales showing the extension of the shelf ice in relation to the bottom as observed January, 1935. Vertical and horizontal scales equal.

indicate that it does so farther south.[9] The minimum depth of 352 meters, shown in Figure 6, was obtained at a point (78° 19′ S., 172° 56′ W.) where the altitude of the barrier above the sea level was about 80 feet, and this would seem, by reason of the buoyancy of the ice alone, to indicate that the edge is afloat. The floor of the Bay of Whales and its relation to the ice as observed January, 1935, are shown in Figure 7. A wire sounding taken while the ship was moored to the barrier on the east side of Eleanor Bolling Bight gave a depth of 642 meters, and one taken three miles farther south while the ship was moored to the bay ice gave a depth of 644 meters. In neither case was there any wire angle noted. A depth of 480 meters was recorded half a mile off West Cape and also at the eastern extremity of the bay, and a depth of 492 meters half a mile off the eastern extremity. Should any point of the shelf ice be grounded in this region, it must be on a pinnacle, or pinnacles, rising steeply from the gentle southward slope. In the region just north of the Bay of Whales the bottom rises to a minimum depth of 179 meters.

Northeastern Sector of the Ross Sea

In 1934 the northeastern sector of the Ross Sea remained a virgin field as regards submarine topography. Soundings on a line from the Bay of Whales to Cape Colbeck and beyond (Fig. 8) were begun as soon as the eastern extremity of the bay was cleared. There is no distinguishing mark or point that can properly be called the east cape. The barrier here curves eastward in a wide sweep, and the extremity of the bay was judged by the visibility of the bay ice and the bearing of the west cape. After the ship had crossed the deep

[9] L. M. Gould: The Ross Shelf Ice, *Bull. Geol. Soc. of America*, Vol. 46 (Part 2), 1935, pp. 1367–1393.

tongue penetrating into the Pennell Bank toward Cape Colbeck, the bottom began to rise gently. It culminated in a ridge at a minimum depth of 89 meters (76° 51′ S., 157° 15′ W.), on which were a great number of stranded icebergs. Through their general direction the ridge could be traced, trending in a northwesterly direction, seemingly as if the Alexandra Mountains were continued beneath the

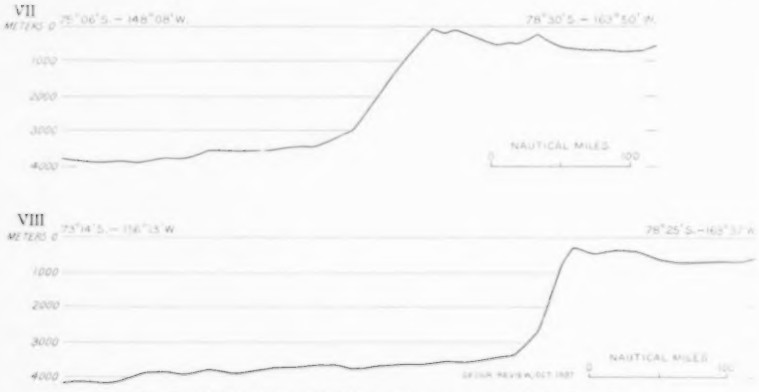


FIG. 8—Profiles VII and VIII, northeastern sector of the Ross Sea.

surface of the sea. From this narrow beginning the bank broadens as it continues across the Ross Sea.

The isobaths east of Cape Colbeck have heretofore been drawn on the assumption that here is a broad continental shelf. However, when the spur off Cape Colbeck had been passed, it was found that the bottom at once receded steeply to 3500 meters, then remained level at 3800 meters for the distance traversed by the *Bear*. While on this section, the ship was forced to alter her course to the north after reaching the farthest east in 75° 6′ S., 148° 8′ W. However, the soundings were continued while the ship was navigating in or skirting the pack ice. The whaling factory ship *Thorshavn* reached a position of 71° 44′ S., 134° 11′ W., on February 10, 1934, and reported a depth of 3722 meters.[10] From this position a flight was made to 72° 8′ S., from which was obtained "a clear sight of the ice barrier about 35 miles south."[11] This would support the belief that the lands in the wide unknown expanse to the south consist of islands locked in an ice-shelf formation similar to the Ross Shelf Ice. In conjunction with the westerly current this also explains the presence off Cape Colbeck of the great number of huge tabular and peculiarly dome-shaped icebergs grounded there.

[10] This is the corrected depth (2204 fathoms) in "List of Oceanic Depths," 1936, Publ. H. D. 347, Hydrographic Dept., Admiralty, London, 1937; see p. 18.

[11] Manuscript report received by the American Geographical Society from Consul Lars Christensen. This may have been only the edge of a large tabular iceberg.—EDIT. NOTE.

These observations remove any doubt that the continental land east of the Ross Sea extends conspicuously northward. The southern limit of the Pacific Antarctic Basin is brought farther to the south and can be separated from the coast by only a narrow strip of continental, or perhaps insular, shelf.

The *Bear* reached her farthest north in 73° 14′ S., 156° 13′ W., and the course was altered to return to the Bay of Whales. Profile VIII (Fig. 8) shows the gentle southward rise of the Pacific Antarctic

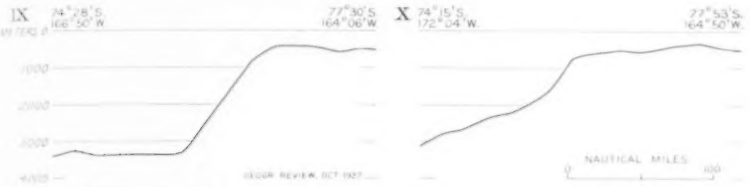


FIG. 9—Profiles IX and X, in the Ross Sea from cruise for rendezvous with the *Discovery II*.

Basin and the steep, almost precipitous slope to the Pennell Bank and the Antarctic shelf. Because of the uniformity of the deeps in the eastern sector of the Ross Sea—which contrasts with the irregularities of the western sector—curiosity was aroused concerning a shallow of 117 meters in 74° 45′ S., 164° 18′ W. shown on the international bathymetric charts. A line of soundings run parallel to the 165th meridian west (Fig. 9) while the *Bear* was en route to a rendezvous with the R.R.S. *Discovery II* revealed depths between 3382 and 3660 meters in these waters.[12]

The floor of this section, bordered on the south by the narrow continental shelf and the Pennell Bank and on the north by a continuation of the great Easter Rise, is a depression. Yet it is not impossible that rocky islands exist therein. Submarine and subaerial volcanic activity is known, and precipitously rising cliffs are not uncommon. One need mention only Scott Island, to the west, and Peter I Island, to the east, as examples.

APPENDIX I—EQUIPMENT AND METHODS

The *Bear* was equipped with a fathometer, of unlimited depth range, manufactured by the Submarine Signal Company of Boston, Mass., before our departure. On a ship of such unusually heavy construction as the *Bear*, an old icebreaker, the installation of the hydrophone and oscillator must differ considerably from the installation on the usual steel ship. The hydrophone tank, containing a deep hydro-

[12] Subsequent communication with the International Hydrographic Bureau, Monaco, in regard to this revealed that the shoal shown on the chart and also a number of other soundings south of this were plotted on the second edition (1912-1925) of the "Carte générale bathymétrique des océans," Sheet C'II, in west longitudes, whereas the longitudes should have been east. These soundings should, therefore, appear on Sheet C'III. They will thus be found located close to the coast of South Victoria Land. The longitudes are correctly given in Part 3 (1914) of the publication "Carte générale bathymétrique des océans," p. 218, and in the "List of Oceanic Depths," 1911, published by the Hydrographic Department of the Admiralty, London, 1912, p. 23.

phone, Type 341 A, was placed in the starboard garboards 3 feet from the keel, where a hole with a diameter of 8 inches had been cut through the planking. The tank was fitted and bolted to the hull so that a part of it protruded 8 inches outside. Around this protruding part was constructed a wooden fore-and-aft fairwater so as to eliminate as much as possible the noises created by the ship's headway. The oscillator, deep Type 324 ("pancake" type), located 12 meters aft of the hydrophone, was set in a heavy steel casting bolted through the hull. Here also wooden fairwaters were constructed. Both instruments were so placed that they would be clear of any ice that might wash downward. To prevent freezing, the hydrophone tank was filled with a solution of equal parts of sea water and an antifreeze mixture.

The sounding unit, operating on a frequency of 525 cycles, was controlled in the laboratory, located below deck off the wardroom aft. The equipment installed did not include an indicator, or automatic timing device, which is usually a part of the fathometer. The outgoing signal was controlled by a key, and the returning echo was received in earphones, the volume being adjusted by an amplifier. The timing was done with delicate, 1/100-second Longines stop watches.

A table converting the time elapsed into depths in meters was constructed based on a sounding velocity of 1500 meters a second (820 fathoms). The stop watches were checked from time to time against the ship's chronometers, but no errors were detected. Steps were taken to guard against error. An average of three series of three soundings each was usually accepted as the depth to be recorded. Allowance was made for personal error, ascertained by constant checking against known depths. On the voyage from Norfolk, Va., to Panama ample opportunity was offered to compare the recorded depths with known depths in well surveyed waters.

A puzzling feature was an inexplicable sudden weakening of the echoes. Soule and Ennis wrote concerning their observations on board the *Carnegie*:[13] "The weakness of the returning echo was a puzzling element which sometimes made sounding difficult—puzzling in its seeming independence of slope, type of bottom, or depth."

The phenomenon was particularly noted in the little-surveyed area of the sub-Antarctic waters between the New Zealand insular slope and Scott Island (67° 24′ S., 179° 55′ W.). The condition of the bottom may have had something to do with this: it is generally believed that a soft bottom has a tendency to return a weak echo. Another explanation may be that, when the rolling of the ship produces an excessive angle between the ocean floor and the face of the hydrophone tank, the incoming echo perhaps is less audible.

For correcting the soundings the British Admiralty tables[14] were used. The tables had to be extended by extrapolation for the deeper waters in their regions 13, 16, and 20. The boundary between regions 20 and 23 along the lines southward from New Zealand could be determined on the basis of surface temperature readings made from the *Bear*. As an average value for draft, 5 meters has been added to each sounding.

Appendix II—The Trans-Pacific Profiles

For completion of the record the trans-Pacific profiles obtained by the *Bear* are given here without discussion.

Profile XI (Fig. 10) was begun off Punta Mala, Panama, and concluded off Tahiti, Society Islands. This fairly well known sector had previously been surveyed by echo-sounding lines from several vessels, notably the *Ara* and the *Carnegie*, Cruise VII.

[13] F. M. Soule and C. C. Ennis: Sonic Depth-Finding on the Carnegie, Cruise VII. *Trans. Amer. Geophys. Union, Tenth Ann. Meeting, April 25 and 26, 1929, Eleventh Ann. Meeting, May 1 and 2, 1930*, Washington, 1930, pp. 264–274; reference on p. 269.

[14] Tables of the Velocity of Sound in Pure Water and Sea Water for Use in Echo-Sounding and Sound-Ranging, *H. D. 282*, Hydrographic Dept., Admiralty, London, 1927.

Profile XII (Fig. 11) was run over a part of the deepest region of the South Pacific. The soundings that have been taken in this region, chiefly those of the *Challenger*, are few and far between. Of outstanding interest is the discovery of the two pinnacles or ridges (*B* and *B'*), in the so-called Aldrich Deep. The deepest readings

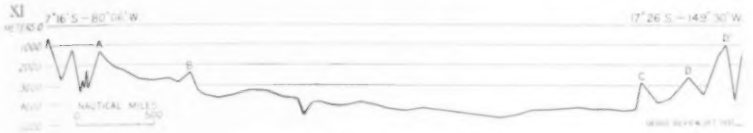


FIG. 10

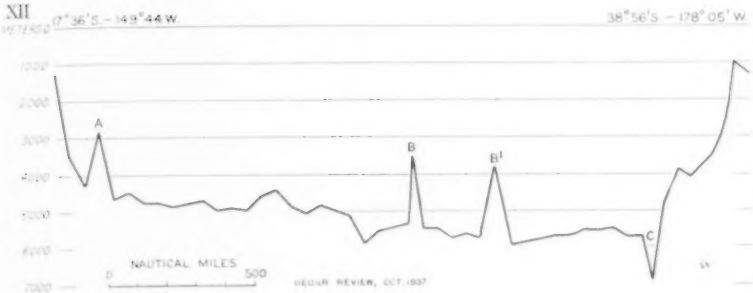


FIG. 11

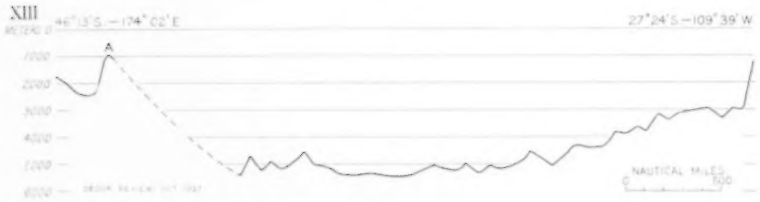


FIG. 12

FIG. 10—Profile XI. Punta Mala, Panama, to Tahiti, Society Islands. A, Cocos Island shelf; B, Galapagos Islands shelf; C, indications of Marquesas shelf; D-D', Tuamotu shelf.

FIG. 11—Profile XII. Tahiti, Society Islands, to New Zealand. A, Cook-Austral ridge; B-B', pinnacles or ridges in the so-called Aldrich Deep; C, Kermadec Deep.

FIG. 12—Profile XIII. New Zealand to Easter Island. A, Bounty-Antipodes ridge. Dotted line indicates lack of soundings.

shown in the profile are identified as the south end of the Kermadec Deep, which, apparently, curves toward the southeast in this sector.

Profile XIII (Fig. 12), New Zealand to Easter Island, crosses a region that has hitherto been a part of the greatest unknown area of the Pacific Ocean. Our previous knowledge of the submarine topography of this region was based chiefly on the line of soundings along the 50th parallel carried out by the U.S.S. *Enterprise* during a trans-Pacific crossing in 1884. As will be noted by comparing this profile with that of Figure 11, the South Pacific Basin deepens considerably to the south before reaching its southern border, the Easter Rise.

II

NORTHEASTERN BORDERLANDS OF THE ROSS SEA: GLACIOLOGICAL STUDIES IN KING EDWARD VII LAND AND NORTHWESTERN MARIE BYRD LAND

F. Alton Wade

IN "Problems of Polar Research" the northeastern borderlands of the Ross Sea—King Edward VII Land and "the lands beyond"—are described as "one of the crucial areas and problems" of the Antarctic: little was known of the area at the time this was written.[1] The First Byrd Antarctic Expedition was able to unveil some of its mysteries. The Rockefeller Mountains, southwest of the Alexandra Mountains, were discovered by Admiral Byrd from the air early in 1929 and were visited by Gould shortly afterward for a reconnaissance survey.[2] Late in 1929, on his important flight northeastward from Little America, Byrd discovered the Edsel Ford Range and named this part of "the lands beyond" Marie Byrd Land. On the Second Byrd Antarctic Expedition, during the summer of 1934–1935, the region was observed from many angles, and more secrets were uncovered. This article is concerned with the geographical and glaciological results obtained by the several parties in the region—the sledge party, of which I was a member,[3] the two tractor parties that entered the area, and the four exploratory flights made over it.

King Edward VII Land

Is King Edward VII Land insular or peninsular? We believe that the data collected by the three field parties working therein and the observations and aerial photographs taken during the flights definitely prove the peninsularity of this land.

The base-laying tractor party, which preceded our sledge party as far as Mt. Grace McKinley, found its way blocked by a system of huge crevasses (Fig. 2) at a point a few miles southeast of the Rockefeller Mountains. This disturbed area was made up of tension cracks, formed where the ice flowed downward from the high land of the peninsula to the level of the Ross Shelf Ice. A passage through the crevasses was found five miles farther south. The ascent began there and continued in huge, terracelike steps for nearly 70 miles. The change in altitude along the trail was from 359 feet on the Ross Shelf

[1] R. E. Priestley and C. E. Tilley: Geological Problems of Antarctica, *in* Problems of Polar Research, *Amer. Geogr. Soc. Special Publ. No. 7*, 1928, pp. 315–328, reference on p. 320.

[2] R. E. Byrd: The Flight to Marie Byrd Land, *Geogr. Rev.*, Vol. 23, 1933, pp. 177–195; L. M. Gould: Some Geographical Results of the Byrd Antarctic Expedition, *ibid.*, Vol. 21, 1931, pp. 177–200.

[3] The sledge party, led by Paul A. Siple, included Stevenson Corey, Olin D. Stancliff, and myself. The party traveled more than 800 miles between October 15 and December 29, 1934. For narrative reports of this and the other explorations in the area see R. E. Byrd: Discovery, New York, 1935.

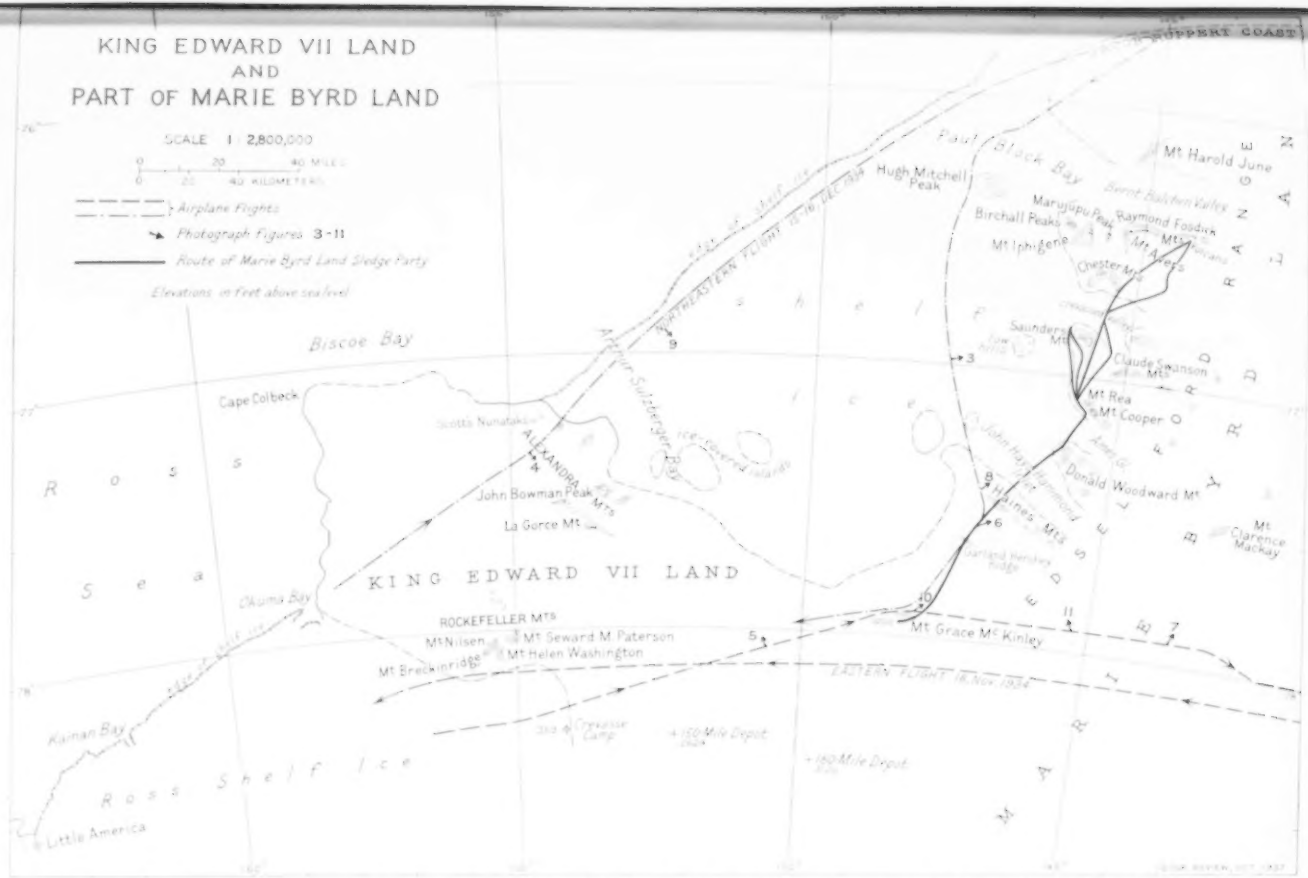


FIG. 1.—Sketch drawn from the reconnaissance map of the northeastern borderlands of the Ross Sea now in preparation by Commander H. E. Saunders. Beside the data obtained by the several parties of the Second Byrd Antarctic Expedition at work in the region use is being made of the aerial photographs obtained by the first expedition, reinterpreted in the light of the additional control points (compare Commander Saunders' map accompanying R. E. Byrd: The Flight to Marie Byrd Land, *Geogr. Rev.*, Vol. 23, 1933, pp. 177–209).

FIG. 2—Giant crevasses characterize the steep border slopes between King Edward VII Land and the Ross Shelf Ice.

Ice to nearly 3600 feet at the crest. The descent to the level of the Shelf Ice near Mt. Grace McKinley (Fig. 1) was more rapid but also steplike. The observations of the tractor party were confirmed by our observations later in the season.

At many points along the trail in the vicinity of 150-mile depot we could see La Gorce Mountain far to the northwest, and at times we were certain that we could see the ice sheet sloping gently downward to this mountain. But one cannot rely on sight alone to establish topographic features in an ice-covered region. For instance, on the outward trip I believed I could see a deep valley separating the Rockefeller Mountains from the Alexandras and so reported to Little America by radio. However, on a flight across this area Admiral Byrd, by means of air soundings, proved that the valley did not exist and that the peninsula included all the mountain groups of King Edward VII Land.

The crevassed area just noted is one of many along this western shore line. The steep slope of the land is reflected on the ice surface by these disturbed areas, but the pronounced change in slope of the ice itself along this line would be enough evidence to indicate and prove

FIG. 3.—An ice-capped island near the eastern edge of the Shelf Ice (off Saunders Mt.).

the existence of this coast. The eastern shore line of the peninsula also is characterized by steep, deeply crevassed slopes. It was observed from the plane from many angles and has, in fact, been seen in its entirety. This shore line can be readily picked out in any of the many aerial photographs taken of this region on the several flights.

The southeastward extension of the peninsula to join the Rockefeller Plateau was proved by the altitude observations of the tractor party. The fact that this ice was definitely resting on land above sea level was established by C. G. Morgan, a member of this party. By means of seismic soundings he determined the thickness of the ice at 25-mile intervals along their route. The greatest thickness recorded was 2100 feet, at an altitude of 3200 feet back of the Alexandra Mountains.[4]

No abrupt change in topography was noted by Ellsworth on his trans-Antarctic flight[5] as he flew from above the higher Hollick-Kenyon Plateau to the lower Rockefeller Plateau. This would indicate an uninterrupted continuation of the underlying land.

The peninsula extends northwestward from the higher mountains

[4] Byrd, Discovery, p. 318, footnote 16.

[5] "Lincoln Ellsworth's Flight Across West Antarctica," *Geogr. Rev.*, Vol. 26, 1936, pp. 329–332.

FIG. 4

FIG. 5

FIG. 6

FIG. 4—A line of ice-covered cliffs extending northwest from La Gorce Mountain, in King Edward VII Land.

FIG. 5—Steep, crevassed slopes mark the position of the northeast coast line of King Edward VII Land peninsula. Two ice-capped [illegible] can be seen protruding through the shelf ice in Arthur Sulzberger Bay.

FIG. 6—The Edsel Ford Range looking north-northeast, from the Raymond Fosdick Mountains and Saunders Mountain on the John Hays Hammond Inlet at the right, with the Haines Mountains in the foreground.

FIG. 7

FIG. 8

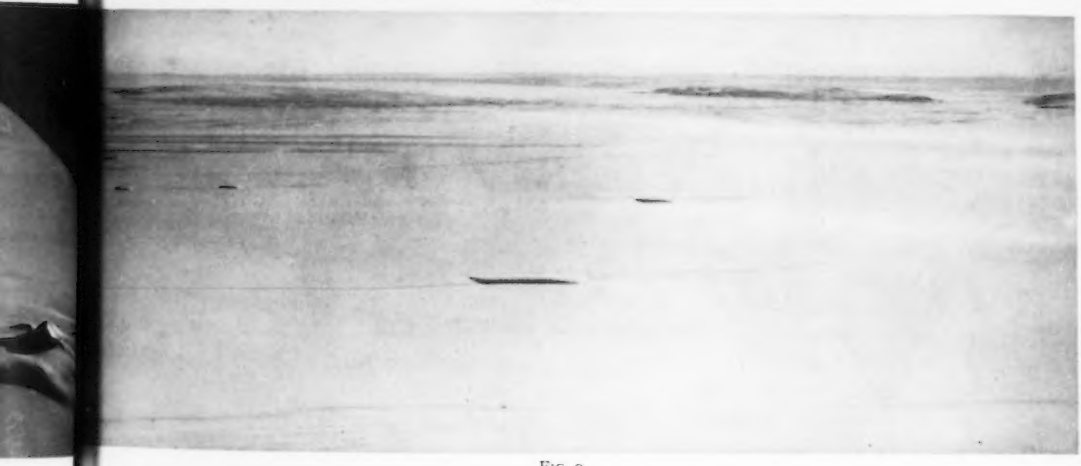


FIG. 9

FIG. 7—The terraced descent from the Rockefeller Plateau to the lower level of John Hays Hammond Inlet.

FIG. 8—The seaward extension of the Haines Mountains appears as an ice-capped ridge in the foreground. Raymond Fosdick Mountains at left; Saunders Mountain at left; Mt. Rea and Mt. Cooper in center.

FIG. 9—Ice capped islands (the three masses in the background) in Arthur Sulzberger Bay. Embedded icebergs in the foreground.

of King Edward VII Land to Cape Colbeck. The pronounced irregularities noted and photographed in this area indicate topographic features on land beneath the ice sheet. Presumably the ground surface slopes gradually downward as Cape Colbeck is approached, but any peaks or ridges that may exist are not high enough to protrude through the ice. The fact that Cape Colbeck, which is indeed only an ice cape, has remained fixed in position for nearly thirty-five years supports the assumption that the ice is definitely grounded at this point. The echo soundings taken during the eastern cruise of the *Bear* indicate that the peninsula continues as a submarine ridge in the Ross Sea.[6] Also indicative of the peninsularity of King Edward VII Land are the air-sounding data obtained by Rawson on the flights over this area. The "soundings" were obtained by skimming the surface and reading the plane's altimeter.

Shelf Ice Between the Edsel Ford Range and the Alexandra Mountains

The area between the Edsel Ford Range and the Alexandra Mountains, which includes Paul Block Bay, John Hays Hammond Inlet, and Arthur Sulzberger Bay, offers an opportunity to study a sheet of shelf ice of moderate size. Our sledge party traversed parts of this formation along its eastern edge, and it was observed and photographed in its entirety by the flight crew on three separate occasions.

Shelf ice may be roughly defined as a floating piedmont. Such sheets, if formed in an indentation of the shore line, as this one is, conform in shape to the limiting boundaries of the indentation and have fairly straight, clifflike faces on the seaward side. The course of our sledge party brought us into the Edsel Ford Range at Mt. Grace McKinley. From the crest of the pink cliffs one can see the greater part of this Shelf Ice stretching seaward, bounded on the northeast by the majestic peaks of this mountain range and on the west by the lower ridges of the Alexandra Mountains, over which the inland ice that caps the King Edward VII Land peninsula pours brokenly. As the icecap decreases in height toward the sea, the peaks of the Alexandras appear and become the restraining wall that borders the northwest extremity of this area.

In its central part the Shelf Ice stretches without a break, except in the vicinity of islands, and slopes gently downward from an altitude of about 2400 feet at the foot of Mt. Grace McKinley to less than a hundred feet at the seaward edge. The entire western shore line of Arthur Sulzberger Bay is distinctly marked by steep slopes where the ice moves downward from the peninsula to the lower level of the bay.

[6] See the preceding article by S. E. Roos: The Submarine Topography of the Ross Sea and Adjacent Waters.

The areas of tension cracks on these slopes are numerous and significant. Leading out from these disturbed areas are large undulations that curve toward the head of the bay, thus indicating that the main ice movement is in that direction (Fig. 5).

The northeastern shore line is highly irregular (Fig. 6). The Edsel Ford Range has been deeply carved by the valley glaciers of the past. Were the ice removed, we should have here a magnificent fiord country. At the head of the inlets the inland ice descends from the higher plateau level to the lower inlet level in broad, terracelike undulations. Where this descent is gradual, as it is at the head of John Hays Hammond Inlet, few crevasses are present (Fig. 7); where the descent is rapid, there are numberless enormous crevasses. Ice-covered ridges extend out from the high land (Fig. 8), and the ice is always greatly crevassed along their margins. Small pressure rolls with axes normal to the direction of maximum slope are generally found at the foot of the slopes on each side of the ridges.

The islands in the Shelf Ice are completely ice-capped. Those near the eastern edge, where the ice is comparatively thick, from a distance and from the air resemble huge pimples on the surface (Fig. 3). The slopes on their borders are fairly gentle; crevasses, naturally, are present, but there is no sharp break in the topography. The islands near the outer edge of the Shelf Ice are distinctly characteristic of a later stage in the glacial cycle. The shelf ice here is comparatively thin and does not override these islands as it did in the past. Many of the gentle slopes have been replaced by sheer cliffs or steep, irregular slopes. It is evident that the seaward face of the ice recedes periodically. Figure 9 shows pieces broken off from the sheet late in an open season and now held fast in newly formed sea ice.

The surface features of the shelf ice, with its characteristic *zastrugi*, were much the same as those observed on the Ross Shelf Ice and on the Rockefeller Plateau.

As our time in this area was so short, and as we seldom visited the same spot twice, it was impossible to take any satisfactory measurements of the rate of movement of the ice. At only one point was a study of the character of the ice made. At a spot a few miles northwest of Saunders Mountain Stancliff descended 30 feet into a crevasse. He reported that the formation was here composed entirely of névé. No glacial ice was observed and no stratification noted.[7]

The Formation of Shelf Ice

Many theories have been advanced to explain the origin of shelf ice in general and of the Ross Shelf Ice in particular. The Ross sheet,

[7] This agrees with other observations made by this expedition but is contrary to previous reports of regular stratification. For example, Dr. Poulter found the layers on the walls of a 30-foot shaft at Little America so short that they could not be traced across the two opposite sides, only four feet apart.

FIG. 10—Icefalls along the ridge east of Mt. Grace McKinley.

as largest existing example of this type of ice formation, has naturally received most attention. Unfortunately, however, all theories regarding its history and origin are based on observations limited to its border areas. Most of the central part has never been seen by man. In his recent paper on "The Ross Shelf Ice"[8] Gould briefly discusses previous theories before presenting his own views:

> The present Ross Shelf Ice is the product of two sets of causes which have rarely, if ever, operated separately. Ice tongues from the inland ice, expanding and coalescing to form piedmonts, have functioned with areas of fast ice to form rafts, or basements, upon which snow has accumulated to become compacted into neve. Melting from below has obliterated the original, or youthful, pattern of the Ross Shelf Ice.

[8] L. M. Gould: The Ross Shelf Ice. *Bull. Geol. Soc. of America*, Vol. 46 (Part 2), 1935, pp. 1367–1393; reference on p. 1393.

FIG. 11—A step in the terraced descent to the Shelf Ice. Here the Haines Mountains (in the background) hold the advancing ice sheet in check.

To this a new point may be added in explanation of the origin of the Shelf Ice under discussion. In the earlier phases of the Glacial period mighty glaciers cut through the coastal ranges and advanced into the bay in the form of floating ice tongues. At the same time icecaps were forming and ever increasing in size on the islands in the bay. Eventually the marginal piedmont, formed by the confluence of the ice tongues, combined, with the aid of interstitial sea ice, with the island ice to form the embryonic shelf ice. It is everywhere evident among the peaks of the Edsel Ford Range that there was a period of much greater glacierization,[9] and very probably the

[9] Using the term suggested by Wright and Priestley. C. S. Wright and R. E. Priestley: Glaciology. British (Terra Nova) Antarctic Expedition, 1910–1913. London. 1922.

inland ice of that time flowed over the mountains in an unbroken sheet and completely filled the bay. Possibly more islands existed then, before the continental depression under isostatic adjustment to the increased load of the icecap at the time of maximum glaciation.

To apply this theory of origin to all formations of shelf ice is not my intention. However, as will be pointed out in a later article,[10]

FIG. 12—From the south the ice sheet slopes gradually upward to the crest of Mt. Grace McKinley.

the role of island ice in the origin of the Ross Shelf Ice is of primary importance and must be given due consideration in theories of shelf-ice formation in general.

THE EDSEL FORD RANGE

The Edsel Ford Range owes its configuration to the combined results of the folding of a series of sedimentary formations, the intrusion of great igneous masses, and the erosive action of local glaciers and continental ice sheets. Structurally the range would seem to resemble more nearly the Graham Land region of West Antarctica than the East Antarctic horst. On the other hand, petrographic examination of the igneous rocks shows them to be of the high sodium and potassium "Atlantic" type rather than the basic "Pacific" type of West Antarctica.[11] Solution of this problem of geological and

[10] By T. C. Poulter and F. A. Wade. In preparation.

[11] Analyses in "Petrologic and Structural Relations of the Edsel Ford Range with Other Antarctic Mountains," to be published in the *Bulletin of the Geological Society of America*.

Compare Duncan Stewart, Jr.: A Contribution to Antarctic Petrography, *Journ. of Geol.*, Vol. 42, 1934, pp. 546–550, for an analysis of rocks collected by Gould in the Queen Maud and the Rockefeller Mountains. "It is concluded that the rocks of the Rockefeller Mountains have close affinities with the high sodium- and potassium-bearing rocks of East Antarctica, and show little affinity with the high calcium-, magnesium-, and iron-bearing rocks of the Andes of South America and the Antarctic Archipelago" (p. 550).

physiographic relationships awaits more field work in the region and in Hearst and James W. Ellsworth Lands.[12] The Edsel Ford region offers readier scope for the study of glacial phenomena.

The icecap which forms the Rockefeller Plateau is impeded in its progress seaward by the mountains of the Edsel Ford Range. As one journeys in a northeasterly direction past Mt. Grace McKinley

FIG. 13—The northern face of Mt. Grace McKinley is an almost perpendicular wall.

and on through the range, the terraced aspect of the fringe of the icecap is very evident. The southern and southeastern snow-covered slopes of Mt. Grace McKinley rise gently to the topmost peaks (Fig. 12) and on the farther side drop in precipitous cliffs eight hundred to a thousand feet high (Fig. 13). The lower peaks of the ridge on each side of the mountain are not high enough to protrude through the ice but do act as a dam, and the ice falls over the ridge to a level some six hundred feet lower. Huge crevasses characterize these ice-falls (Fig. 10). From the foot of this step the ice surface rises gradually to Garland Hershey Ridge and falls to a new low on the seaward side. The Haines Mountains may be considered a third step in the terrace (Fig. 11). As the principal movement of the ice is down the valleys towards the Shelf Ice, the gradual increase in thickness of the ice as one travels northward between the ridges is probably due to the accumulation of wind-driven snow in the lee of the ridges.

The icecap has receded sufficiently to leave the more northern peaks—Mts. Cooper, Rea, Saunders, the Chester Mountains, etc.—bare of ice and snow except on flat crests and in local catchment basins. Valleys have been carved through the range by glaciers of

[12] W. L. G. Joerg: The Cartographical Results of Ellsworth's Trans-Antarctic Flight of 1935. *Geogr. Rev.*, Vol. 27, 1937, pp. 430–444.

FIG. 14

FIG. 15

FIG. 16

FIG. 14—Looking down across the terraced terminal moraine, Mt. Rea, to a blue-ice lake below.
FIG. 15—Highland ice topping the lower peaks of Mt. Rea.
FIG. 16—A lateral moraine near Mt. Rea.

the past; today the glaciers in these valleys are comparatively thin, slowly moving sheets of ice that descend gently from the base of the steep slopes and icefalls at their heads to their outlets at the Shelf Ice. That they are not stagnant is evidenced by the disturbed shear areas along their borders. The area of greatest disturbance that we noted was a narrow zone parallel to Mts. Rea and Cooper at a distance of about a mile. It was characterized by numerous small crevasses and "haycocks," many of the latter rising to a height of more than six feet.

Siple and Corey were forced to detour round an extensive deeply crevassed region (76° 45′ S., 145° 30′ W.) while on their trek into the northeastern part of the range. This disturbed area occupies a large basin of 25 to 30 square miles, surrounded by mountains. The crevasses, except for the marginal shear cracks, are mostly tension cracks, formed as the thin ice passes over irregularities in the basin floor.

In the vicinity of the bare rock peaks many small, blue-ice lakes were observed. During the midsummer days much snow melts on the mountain slopes near the bare exposures and runs off into the snow fields at the foot of the slopes, where it mixes with the unconsolidated snow, freezes, and forms this hard, so-called "blue ice."

Many indications of former greater glacierization were seen. The flat, bare exposures on the heights of Mt. Grace McKinley and on Garland Hershey Ridge are deeply gouged and striated. The rather flat crest of Mt. Donald Woodward, about six hundred feet above the present level of the broad valley glaciers on each side, is deeply striated and exhibits chatter marks and crescentic gouge marks.

The most striking evidence came from the Rea-Cooper massif, the highest of whose precipitously cliffed, pink, granite peaks rises 2800 feet above the level of the shelf ice. Remnants of mountain-glacier valleys may be observed at many points. One peak in particular owes its peculiar pyramidal shape to the cutting action of glaciers on three sides. Great piles of morainic material lie at the bases of the three slopes. One of these piles, arranged in terraced steps, was interpreted as a receding series of terminal moraines (Fig. 14). An unmistakable U-shaped glacial valley cutting across one of the higher peaks of the massif implies a former active mountain glacier at a level 2000 feet higher than that of the nearest active ice today. The sheer cliffs characteristic of this mountain owe their formation to the splitting off of huge tabular slabs as a result of frost action along vertical joints. Many glacial features have thus been erased. Two moraines, the only extensive lateral moraines observed throughout the entire area, extend out for about two miles from the western base of Mt. Rea in a thin ice area (Fig. 16). All other glacier-transported debris has disappeared from sight in the ice of the slow-moving outlet glaciers.

III

THE THORNE GLACIER SECTION OF THE QUEEN MAUD MOUNTAINS

Quin A. Blackburn

AMONG the accomplishments of the First Byrd Antarctic Expedition, 1928–1930, was a geological reconnaissance in the Queen Maud Mountains, the great mountain wall that marks the descent from the South Polar Plateau to the southern extremity of the Ross Shelf Ice.[1] To carry the reconnaissance farther was one of the objectives of the Second Byrd Antarctic Expedition, 1933–1935.

The plans called for the Geological Party to bear directly for Supporting Party Mountain (85° 28′ S., 147° 40′ W.), which marked Gould's easternmost point along the base of the Queen Maud Mountains; thence a course was to be taken eastward and southward up the first great outlet glacier furnishing a feasible route to the South Polar Plateau. The party set out from Little America on October 16, 1934, and returned January 11, 1935, having thus spent 88 days in the field.[2]

Crevassed Areas of the Ross Shelf Ice

The well known crevassed area extending southward from the 173-mile depot (81° 9.6′ S., 161° 5′ W.) was traversed for about seven miles.[3] On our course it consisted of roughly parallel folds, trending about east-west and reaching a maximum of 30 feet from trough to crest; however, because of the width of the spacing the altitudinal differences were not very apparent. In addition there were the familiar "haycocks" as well as crevasses and filled lenticular holes arranged somewhat in echelon.

A low elevation in the surface of the Ross Shelf Ice was encountered at 83° 18′ S., 157° W., where the barometer indicated a rise of 200 feet. A more prominent elevation was visible east of the 350-mile beacon (83° 56.5′ S., 153° 40′ W.). Extending about nine miles southward from this last position was a belt of greatly disturbed surface marked by hummocks, crevasses, holes, and monoclinal ridges, all trending roughly southeast-northwest.

[1] L. M. Gould: Some Geographical Results of the Byrd Antarctic Expedition. *Geogr. Rev.*, Vol. 21, 1931, pp. 177–200.

[2] It consisted of Stuart D. L. Paine, navigator and radio operator, Richard S. Russell, Jr., in charge of transport and supplies, and myself as leader and geologist and surveyor. In addition to tractor support to 173-mile depot, there was a supporting party consisting of Albert Eilefsen and F. Ronne, who accompanied us as far as mile 293 placing depots for our return.

For a narrative of the trip see R. E. Byrd: Discovery, New York, 1935, pp. 360–370

[3] All miles are nautical. Many of the figures for positions, distances, azimuths, and elevations are approximations subject to subsequent modification. The preliminary nature of this report should be emphasized: much time will be required for the full working up of field notes and collections.

FIG. 1.—Sketch based on the reconnaissance map of the Thorne Glacier region now in preparation by Commander H. E. Saunders. (Because of the great wealth of material in the form of photographs and triangulation data furnished by the geological party and the fact that some features have been identified on the aerial photographs taken on the South Pole Flight of November, 1929, the map has not yet been completed. Pending its completion it should be noted that names are not final.)

An area of long rolls, trending east-west, was entered at 84° 14′ S., 152° 40′ W. The crests of the rolls were from two to six miles apart and from 100 to 200 feet above the troughs. Thirteen miles beyond the 375-mile depot huge bridged crevasses were encountered trending north-south, 10 to 30 feet wide and of great lateral extent. Another belt of filled crevasses extended southward for ten miles from the 400-mile depot. Here there were also distinct rolls and clean-cut cracks, trending about east-northeast and west-southwest. Between mile 413 and mile 416 were many large crevasses, some of considerable lateral extent, others lenticular. Beyond, to the base of the frontal mountains, the surface was relatively free from pressure phenomena.

Selection of Route from Mountain Base

Twelve miles from Supporting Party Mountain the "Mountain Base" (85° 16.2′ S., 148° 46′ W.) was established. The mountain was ascended, and on the summit Gould's cairn and note were found. From this vantage point it was clear that, within the range of visibility, Lev-

Fig. 2

Fig. 3

Fig. 4

Fig. 2—Durham Point from the summit of Mt. Durham, looking northwest from station 14.

Fig. 3—Mountains on east side of lower Thorne Glacier (note [illegible] ice). View from northwest near station 13. Mt. Hamilton on right.

Fig. 4—Low mountains on east side of lower Thorne Glacier [illegible] Mt. Hamilton. View from west near station 13.

FIG. 5

FIG. 6

FIG. 7

FIG. 5—Looking east from the summit of Mt. Durham. The Thomas Watson escarpment extending far east into Marie Byrd Land.
FIG. 6—Looking east-southeast from just south of Mt. Hamilton up Phillips Glacier; Thomas Watson Escarpment in background.
FIG. 7—Buttressed peaks just north of Darryl Zanuck Mountain.

erett Glacier did not offer the hoped-for road for execution of our plans. The Thomas Watson Escarpment, which represents the fault-line scarp of the Polar Plateau, some thirty miles to the south, was apparently uninterrupted by any great outlet glacier that might afford a way to the interior. Moreover, the tabular mountains at the edge of the Plateau appeared, progressively eastward, to be lower and more and more mantled with snow. On the other hand, Thorne Glacier, to the west, headed back toward sharp ranges with less snow and better promise of a route to the interior; hence this glacier was selected.

From Supporting Party Mountain Leverett Glacier was revealed as a broad terrace more than 20 miles wide extending from the fault-line scarp of the Plateau with gradually decreasing surface elevations toward the Ross Shelf Ice, into which it merged at steep gradients among the nunataks and through an unobstructed channel eight miles wide to the west.

Several of the nunataks to the west were visited and were found to be composed of gneiss with quartz veins carrying small amounts of chalcopyrite.

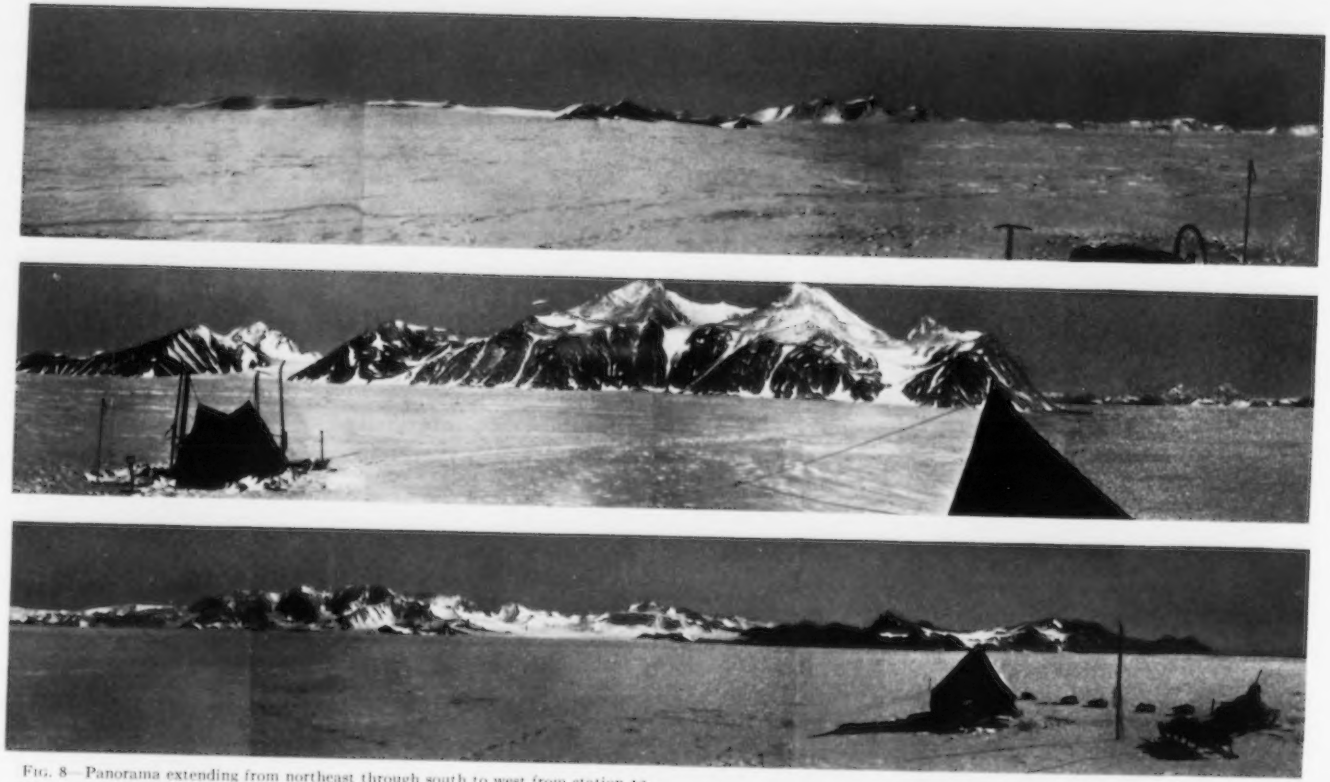


FIG. 8—Panorama extending from northeast through south to west from station 12.

The top section looks across Phillips Glacier to Mt. Gould in the right center. The middle section shows Mt. Danforth to the left, Darryl Zanuck Mountain in the center (note shrunken cirque glaciers and abandoned cirques), the mid-glacier granitics in the right distance. The bottom section looks across Thorne Glacier to the Faulkner Escarpment on the left, Will Hays Mountains in left center, Mt. Griffith in center, Mt. Pulitzer in right center, behind the rock wall.

Mountains in left center, Mt. Griffith in center, Mt. Pulitzer in right center, behind the rock wall.

FIG. 9

FIG. 10

FIG. 11

FIG. 9—Panorama looking generally southwest from station 13. Mt. Hamilton on left, Will Hays Mountains, and rock wall.

FIG. 10—Panorama to southwest and west from station 3. Mt. Innes-Taylor in extreme left background, Mt. Jane Wyatt and Frederick H. Rawson Mountains in left center, Mt. Farley at right, and Faulkner Escarpment in right distance.

FIG. 11—Panorama from a point between stations 2 and 3. Mt. Jessie O'Keefe to left, Mts. Grier, Thurston and Katharine Paine in center; icefalls to right.

The route led over seven miles of rippled blue ice followed by four miles of rolls and crevasses, spaced well apart and having about north-south axes. In the glacial lee of the subdued range of low, rounded summits forming the eastern portal of Thorne Glacier was a wide depression with a greatly wind-etched snow surface. Durham Point (Fig. 2), of gray, granitic rock much cut by dikes of what seemed to be diabase, extended northward in acute termination of these moun-

FIG. 12—Panorama west from station 9. Mid-glacier granitics (left), Faulkner Escarpment, Will Hays Mountains (right).

tains of the eastern portal. About a mile to the east the granite cliff face was cut by large dikes of pegmatite. At the base of the cliff and parallel to it was a long, narrow depression floored with rippled blue ice, which cracked intermittently with loud reports, evidently contracting with a lowering temperature.

LOWER THORNE GLACIER

Up Thorne Glacier the mountains gradually became more serrate, with cliffed faces to the glacier (Fig. 3) and pegmatite dikes much in evidence. Numerous cols in the ridges permitted the prevailing easterly winds to aggrade long snow slopes out on the glacier (Fig. 4). About twelve miles up from Durham Point Phillips Glacier entered from the east. It was about ten miles wide and seemed to be continuous with Leverett Glacier except where it was interrupted by several low ridges and by groups of peaks with summits rounded and corniced by snow mantling.

From triangulation station 12, at 85° 49.7′ S., 151° 10′ W., on this tributary glacier a bearing of S 79° 10′ E (true) marked the eastward disappearance from view of the fault-line scarp of the high plateau (Figs. 5 and 6). This same fault-line scarp was observed to turn abruptly to the southwest about twenty miles east-southeast of this station. Several miles south of station 12 lay the northern base of Darryl Zanuck Mountain, a rugged granitic massif, reddish brown in color, trending about east-west. Northern shoulders of its serrate peaks were characterized by shrunken glaciers and abandoned cirques (Fig. 8). To the east was a mountain of black rock, much mantled

with talus, and bearing faceted spurs on its flanks. Beyond, to the southeast, was Mt. Danforth, reddish brown in color.

Beyond Thorne Glacier to the west of this station was the towering massif of the Will Hays Mountains (Fig. 8), of grayish-brown, apparently igneous rock, showing prominent joint planes, inclined to the southeast. Summit arêtes were conspicuous and connected the group to a northwestward-trending range of gabled peaks, pre-

FIG. 13—Panorama north from the base of Darryl Zanuck Mountain. Mt. Hamilton in the center background. The medial moraine marks the confluence of Thorne (left) and Phillips (right) Glaciers.

sumably of the same character. Southeast of the group and with the same axial trend, but separated from it by a tributary glacier in a terraced position at the base of the fault-line scarp, was a similar high-standing group, with several prominent summits, which were tentatively referred to as the mid-glacier granitics (Fig. 12). Along the base of this general system and bordering Thorne Glacier were numerous low, triangular peaks and long, acute ridges. Toward the western portal of the main glacier extended a system of smaller peaks, of dark material, having numerous serrate summits but generally showing somewhat smoothly rounded topography. Along Thorne Glacier this foothill system was cut off in a well defined wall (Fig. 9). Farther northward and northwestward the forepeaks seemed to be nunataks.

TRIBUTARY GLACIERS

Thorne Glacier showed many pressure phenomena. A longitudinal maze of great open pits and chasms, rolls and séracs extended about two-thirds of the length of the glacier. Because of their greater surface gradients the larger tributary glaciers entered the Thorne as ridges or tongues extending far out into the main ice stream. On the lower and middle glacier the typical confluence was marked on the upstream side by steep-sided rolls and a depression just above on the main glacier.

From the northwestern base of Darryl Zanuck Mountain (Fig. 8) a medial moraine (Fig. 13), occupying a marked depression, extended out toward mid-channel, bending down-glacier in curves with large radii and marking the upper line of confluence of Thorne and Phillips

Glaciers. The morainal material ranged in size from coarse sand to huge, angular blocks. Another such moraine, though less prominent, was found several miles above Durham Point.

Extensive lateral moraines at the base of some of the mountains and talus slopes on others attested to rapid rock disintegration. Weathered granitic surfaces were various shades of red and brown; fresh surfaces were grayish. Where disintegration was not too rapid, especially on cliff faces, there was much evidence of wind etching. Some of the smaller aiguilles were pierced or even riddled with holes. Along the upper half of the glacier the evidence of wind abrasion was inconspicuous: because of the greater snow mantling the winds were less plentifully supplied with abrasive material.

As travel up-glacier was continued, more mountains came into prominence to replace those lost to view over the northern horizon. Every few miles of travel revealed another tributary glacier, generally descending rather steeply from an amphitheater encircled by towering granitic peaks, in some cases issuing from elongated valleys leading

FIG. 14

FIG. 15

FIG. 16

FIG. 14—Massive buttressed peaks (Mt. Danforth to left) east of Datyl Zanuck Mountain. Looking northeast from a point about a mile and a half north of station 9.

FIG. 15—At the right are the Organ Pipes, aiguille type of peaks north of station 9.

FIG. 16—Part of the Organ Pipes from near station 9.

FIG. 17

FIG. 18

FIG. 19

FIG. 17—Mt. Gardiner looking southwest across Thorne Glacier from a point between stations 6 and 7.

FIG. 18—Mt. Czegka (extreme left) and Mt. Jessie O'Keefe from the southwest at station 5 (Confluence of Glaciers camp).

FIG. 19—Mt. Katharine Paine (left) with low hills of black porphyritic material in front, Mt. Thurston, Mt. Grier, from the north (station 5).

laterally among minor ranges. There massive buttressed peaks (Fig. 14) toward the head of the valley merged into an arc of mountains more of the aiguille type (Figs. 15 and 16). Sculpture was controlled by the nearly vertical jointing of the granitic rock, which appeared pink on weathered faces.

Up glacier to the southwest of Darryl Zanuck Mountain a very large tributary, Bob Bartlett Glacier, entered Thorne Glacier from the south. The massive Mt. Gardiner (Fig. 17) lay between the two glaciers just above their junction. At "Confluence of Glaciers" camp, 86° 24.9′ S., 148° 43′ W., a huge tributary from the southeast joined Thorne Glacier, giving rise to pronounced pressure manifestations over an extensive area. The upper part of the tributary was divided into several branches and diverged widely at its head to merge into the Polar Plateau, where a few low nunataks were visible.

SEDIMENTARY MOUNTAINS

Northeast of this camp was the imposing mass of Mt. Jessie O'Keefe (Figs. 11 and 18), together with its flanking gendarmes. Resting apparently on a broad, igneous base were

probably two thousand feet of nearly horizontal bedded sediments of alternating buff, brown, and black, capped by several hundred feet of brown, apparently igneous material. Marking the base of the sediments was a prominent ice cliff of sapphire blue, of considerable lateral extent. From the northwest it was observed that the horizontal bedding of this mountain continued northeastward, apparently joining with the plateau scarp seen from triangulation station 12. On the southeast the flat-topped, igneous base of Mt. Jessie O'Keefe was devoid of sediments and seemed to extend eastward.

From this same position (triangulation station 5) the mountains to the west beyond Thorne Glacier were observed to be mostly of the gable type, though some terminated southward in long, acute ridges. Because of the greater inundation by the glacier, the forepeaks at this latitude seemed to be of no greater altitude, even of considerably less altitude, than those farther down-glacier. Individual mountains and mountain groups tended to be more isolated. Rocks of the forepeaks were black and brown, apparently igneous.

FIG. 20

FIG. 21

FIG. 22

FIG. 20—Mt. Weaver from the north (station 1) showing stratification and minor faulting and the igneous base on the lower right.

FIG. 21—The northeast shoulder of Mt. Weaver from station 1 showing unconformable contact of sedimentaries and granitic base.

FIG. 22—Mt. Saltonstall and Mt. Innes-Taylor (right), and Poulter Glacier from station 2.

FIG. 23

FIG. 24

FIG. 25

FIG. 23—Poulter Glacier. Mt. Jane Wyatt, and Faulkner Escarpment (extreme right). View to southwestward of station 2.

FIG. 24—Mt. Jane Wyatt at left; large filled crevasse in foreground. En route between stations 2 and 3.

FIG. 25—Between Mt. Wilbur to the left and Mt. Weaver to the right the Polar Plateau is seen stretching southward. View from northeast at station 2.

To the south-southeast was a long, low line of undulating hills, of black, porphyritic material. Those on the south were separated by a pronounced gap from a high tableland of similar dark rock, having on its margins, especially on the northwest and southeast, numerous gable mountains, some of them heavily snow-mantled (Fig. 19). The edges of this "mesa," where not bordered by such mountains, plunged abruptly to the glacier (Fig. 11). Parallel to the northern edge of the system was a series of transverse rolls of rippled blue ice, their crests surmounted by heterogeneous rock debris.

SOUTHERNMOST CAMP AT MOUNT WEAVER

The southernmost camp (86° 57.5′ S., 152° 20′ W.) was located at the northeastern base of Mt. Weaver (Figs. 20 and 21), the nearer summit of which was less than two miles distant. This mountain is a slightly synclinal ridge about four miles long trending generally east and west. Sedimentary beds extended from about 300 feet above camp (at an altitude of 7510 feet) to about 120 feet below the summit

(at 9880 feet).[4] The base of the sediments seemed to be in contact with a dark, fine-grained igneous rock, which rested unconformably on a rolling granitic surface. The sediments consisted of numerous alternations of shales and sandstones with intercalated coal beds. Near the base were conglomerates of milky quartz pebbles in a dark-green matrix. The sandstones were thinly laminated to massive, and some were cross-bedded. Shales ranged from a few inches to 40 feet in thickness, and some graded into sandstones. Some carbonaceous shales seemed to be the source of numerous clay-ironstone nodules. The coal beds ranged from a few inches to more than 10 feet in thickness; the coal ranged from lignitic to, possibly, bituminous. The topmost sedimentary bed was heavily plant-bearing, and many leaves and stems were in evidence. Numerous fossil tree sections attaining a maximum of 18 inches in diameter were found on the moraines.

Cutting the escarpment face of Mt. Weaver were several sills and dikes of fine-grained, green igneous rock, which weathered to a deep reddish brown. The summit rocks for a thickness of about 170 feet were apparently of the same nature. The sills, traced laterally along the cliff face, were vertically interrupted by several faults of no great displacement. Snow mantling, the mask of rubble, or steepness of slope made observation of contacts of the different members difficult.

The Head of Thorne Glacier

From the summit of Mt. Weaver the physiographic relationships at the head of Thorne Glacier were visible. A line of tabular mountains, apparently of the same character as Mt. Weaver, trended northwestward, showing nearly horizontal sediments, which, in those nearer at least, seemed to dip slightly to the southeast. To the northwest beyond Poulter Glacier were several prominent, dome-shaped peaks. Farther away in the same general direction these tabular mountains became less individually distinct in the high ridge of which they formed a part. Toward Thorne Glacier, on the east and northeast, the range showed the cliffed faces of an apparent fault-line scarp (Fig. 23). The southern slopes of these mountains seemed less precipitous than the northern and northeastern. But as the southern slopes represented the stoss side in relation to the Polar Icecap and also the windward side, the difference may have been more apparent than real.

About 35 miles northwest of the summit of Mt. Weaver lay Mts. K. Prestrud, Olav Bjaaland, and Sverre Hassel, in the form of a long, low, north-south ridge, considerably masked in snow and ice. Probably three miles to southeastward was a prominent gable peak (Fig. 25), a nunatak characterized by dark, horizontal bands. Far to the southeast, probably 15 or 18 miles away, was Mt. Louis McHenry

[4] Barometer readings are only relative.

Howe, a group of nunataks, consisting of low connecting ridges and minor gable peaks. Another group of nunataks, somewhat nearer and more to the north, seemed to be of the same general character. Reddish-brown rocks were visible in both groups. About four miles to the northeast was a mountain of granitic material—gray, weathering to pink, Mt. Wilbur (Fig. 25). Its flat mesa top was probably 1000 feet lower than the summit of Mt. Weaver. Its western flank rose as a precipitous wall. On the south, or stoss, side the ice reached nearly to the summit of the mountain; less than two miles away at the northwest end the ice was about 1000 feet below the summit.

Off to the northeast appeared the "mesa" of dark rock sighted to the south of the Confluence of Glaciers camp. On the southwest and south it plunged abruptly in cliffs to the glacier level. The nearly flat top seemed to incline gently eastward. The fringing mountains, Katharine Paine, Thurston, and Grier (Figs. 11 and 19) seemed to have an accordance of summit levels. Beyond this system other groups of peaks and nunataks extended indefinitely northeastward.

To the south, with the exceptions mentioned above, no rock exposure was visible. The main glacier merged imperceptibly into the Polar Plateau. Along the near-by mountains the surface gradient was steep for several miles; beyond, there was little appearance of much additional increase in elevation southward. In the area of steeper gradient several rolls and domed bulges with well developed systems of crevasses and séracs interrupted an otherwise smoothly undulating surface that continued to the southern horizon.

General Structure of the Mountains

As Gould pointed out, the topographic expression of the Queen Maud Mountains is in accord with its relatively simple geological structure. He has described this structure for the section about Mt. Fridtjof Nansen.[5] Only about a hundred miles beyond the western limit of Gould's reconnaissance is Beardmore Glacier. The relationships of structure and age of the mountain systems of South Victoria Land from Beardmore Glacier to Cape Adare have been described by the geologists of the Scott and Shackleton expeditions. "The structure of the Queen Maud Range is an exact duplicate of that of South Victoria Land north of Beardmore Glacier and possesses the same stratigraphic relationships."[6] In the area investigated by our party the same general relationships were noted.

Pre-Cambrian basement rocks consist of highly folded and contorted schists and gneisses. Resting on these are younger, granitic rocks thousands of feet thick, which in turn support at least two

[5] Gould, *op. cit.* See also his "Structure of the Queen Maud Mountains, Antarctica," *Bull. Geol Soc. of America*, Vol. 46 (Part 1), 1935, pp. 973-983.

[6] Gould, Structure of the Queen Maud Mountains, p. 979.

thousand feet of sedimentary beds. The whole is cut by dikes and sills of a dark, fine-grained, igneous material, which, in some places at least, also caps the sediments. The elevated position of these sedimentary beds—exposed on Mt. Weaver between 7900 and 9750 feet—coupled with their relatively little disturbed attitude suggests that the tabular mountains are eroded remnants of a great horst, or of several horsts, with a relative vertical displacement of nearly 10,000 feet. As Gould indicated, the northern scarp of this Queen Maud horst is marked by the outer limit of the comparatively low and, in some places, smoothly rounded minor ranges and nunataks of pre-Cambrian metamorphic rocks and younger granites. Intermediate in position between the frontal ranges and the tabular mountains are the massive granitic mountains especially in evidence along the flanks of so great an outlet glacier as the Thorne. These intermediate ranges, not completely overridden by ice during periods of maximum glacierization and subject to rapid weathering of the alpine type, more generally show serrated and gabled peaks and arêtes. On the other hand, the tabular mountains, capped by relatively resistant igneous sills, represent the higher, less eroded remnants of the horst. Their broad domes with precipitous fronts to the north and northeast are expressive of their nearly horizontal bedding and protective capping.

The maximum width of the horst in the Thorne Glacier area seems to be about 100 miles. Its southern fault-line scarp may be represented—northwest of Mt. Weaver at least—by the probably less precipitous slopes of the tabular mountains to the Polar Plateau. The actual scarp is possibly farther southward.

The sediments are correlative with the Beacon-sandstone series of South Victoria Land, which has been described by Ferrar and others as ranging from Devonian to Permocarboniferous. Future study of the fairly extensive fossil-plant collection may throw additional light on the matter of correlation.

The suggestion of previous investigators that the great outlet glaciers probably occupy the positions of transverse faults athwart the horst would seem to be valid. Observations made in traversing the length of Thorne Glacier offer some substantiation of this hypothesis. Except for apparent absence of low mountains of metamorphic rocks along the glacier except near its confluence with the Ross Shelf Ice, the relation of the high granitic ranges to the tabular mountains is much the same along the flanks of the glacier as parallel to the general trend of the Queen Maud horst; i.e. the granitic ranges outwardly flank the tabular mountains—an indication that they are dissected parts of the horst, from which the sediments have been removed. However, this relationship could have resulted from erosion. The present volume of the glacier and its apparent rate of motion (judging

from pressure manifestations)[7] seem inadequate to explain the deepness of the glacial trench and the width of the gap in the sedimentary series across the glacier.

The large "mesa" of black, igneous material northeast of Mt. Weaver and its bordering mountains, Katharine Paine, Thurston, and Grier, all with more or less accordant summits and bearing no visible sedimentaries, seemed to reach greater altitudes than the base of the sediments on Mt. Weaver, possibly as a result of differential uplift. As was noted above, the sedimentary strata on Mt. Weaver had been disturbed only slightly.

It is possible that, from his South Polar route to westward, Amundsen sighted the tabular mountains bordering the upper reaches of Thorne Glacier on the west and that from them he got the impression that the Queen Maud Mountains extended well out on the Polar Plateau, if not beyond the Pole. However, it now seems that this arcuate trend of sedimentary mountains disappears slightly beyond 87° S. On the other hand, the structural equivalents of these mountains, with their prominent apparent fault-line scarp, are found on the east side and adjacent to Thorne Glacier in a more northern position (about the 86th parallel). From this locality the axial direction is apparently northeast for a short distance and thence east, with possibly some northing.

The facts that, although in some exposures the members of the Beacon series are practically horizontal, in others the slight dip seems to be prevailingly southeast or east-southeast and that the mesalike summits of some of the igneous forms of the upper glacier incline in the same directions would indicate that the progressively lower stand of the Queen Maud Mountains eastward is a result of a relatively smaller vertical displacement of the horst in that direction.

Relation with Edsel Ford Range?

Field observations furnished some slight indication that the Queen Maud Mountains and the Edsel Ford Range are connected by an elevated land mass, though the evidence was not conclusive. There seems to be a small northern component in the easterly trend of the nunataks and forepeaks beyond Supporting Party Mountain and also in that of the apparent fault-line scarp of the plateau east of the same mountain.

More significant is the trend of pressure ridges and crevasses at the confluences of Thorne Glacier and the wide western outlet of Leverett Glacier with the Ross Shelf Ice. The pressure rolls or ridges and the major crevasses extend down-glacier at acute angles

[7] An attempt at actual measurement was not successful, but the time interval—two to three weeks—was necessarily short.

to their respective glacial axes. But within a short distance of their mergences into the Ross Shelf Ice rolls and crevasses bend in long compound curves to the northwest. This is indicative of movement from the east of the Ross Shelf Ice along the base of the Queen Maud Mountains. Leverett Glacier did not seem to be the principal source of the volume of ice necessary to cause this pressure—not, at least, as regards its large western outlet. Such a pressure would seem to call for a relatively high plateau to the east from which a vast quantity of ice would pour northwestward. The appearance of a distinct rise east of the 350-mile depot is rather suggestive, though not in itself important.

Some support may also be drawn from the prevalence of southeasterly winds on the Ross Shelf Ice between about 83° 10′ S. and the base of the Queen Maud Mountains. Both crossings of this area—an area of ablated and abraded surface with pronounced directional *zastrugi*—revealed the persistence of this general air movement. Nearer to the mountains the wind direction became more easterly until it was about parallel to the trend of the frontal ranges, a fact that suggests the gravitational downdraft from the elevated land mass to the east. On Thorne Glacier a persistent and strong downdraft from the Polar Plateau was the rule under apparently normal atmospheric conditions. But, although on the lower glacier the easterly winds swept through the cols in the low mountains, the minor-tributary gathering basins up-glacier on the east side were relatively calm. Of course, this was not true of the major tributaries that descended directly from the Polar Plateau and which were characterized by downdrafts. Conclusive proof of the existence or nonexistence of such a land mass east of the Mountain Base will be furnished only by an aerial or other reconnaissance in that direction.

OHIO TOWN PATTERNS

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THE patterns of the Ohio towns betray their origin. Whether the towns are on the Allegheny Plateau, the Till Plain, or the Lake Plain,[1] and whatever the changes incident to the economies through which the regions have passed, the persistence of original orientation and pattern is striking.

The Northwest Territory, as the first considerable area of public land in the United States, and Ohio, as the first state created from this territory, were the scenes of much pioneering in matters of survey, grants, and formation of minor civil subdivisions. Some settlements were made because land could be obtained cheaply, some to satisfy military warrants, some to recover money lent to the colonies, some to satisfy colonial claims, and some to induce the opening of roads, canals, and schools.

Until the rectangular plan was adopted in 1785, all tracts of land in the United States were subdivided and described on the so-called "indiscriminate locations" plan. Consequently all lands in the states southeast of the Ohio River and east of the Mississippi, except parts of Alabama, Mississippi, and Florida, have been subdivided and described in that manner.[2] Elsewhere in the United States, except for the Virginia Military District in Ohio and certain small special grants in other states, the rectangular plan has been used.

Elements of Pattern

Two of the basic elements of the Ohio town pattern are the orientation and form of the town and its relation to the road system. A regional distribution of patterns can be recognized. Towns having a population of more than 500 and not oriented to the cardinal points of the compass characterize three peripheral regions, the principal ones being in southern and eastern Ohio and a minor one on the Lake Plain, in the north. The first two are in the part of Ohio first opened to settlement, south of the Greenville Treaty Line. Not all of this part of the state shows eccentric orientation, nor is the degree of eccentricity everywhere the same, as will be noted subsequently. Furthermore, there is a definite accordance between eccentric orientation and a radial road system.

[1] See, for example, Guy-Harold Smith: A Population Map of Ohio for 1920. *Geogr. Rev.*, Vol. 18, 1928, pp. 422–427, Pl. IV and Fig. 1. See also his "The Relative Relief of Ohio," *ibid.*, Vol. 25, 1935, pp. 272–284, Figs. 1 and 2.

[2] C. E. Sherman: Final Report, Ohio Cooperative Topographic Survey, Vol. 3, Original Ohio Land Subdivisions, Columbus, Ohio, 1925, p. 5. See also W. E. Peters: Ohio Lands and Their History, 3rd edit., Athens, Ohio, 1930, map p. 38.

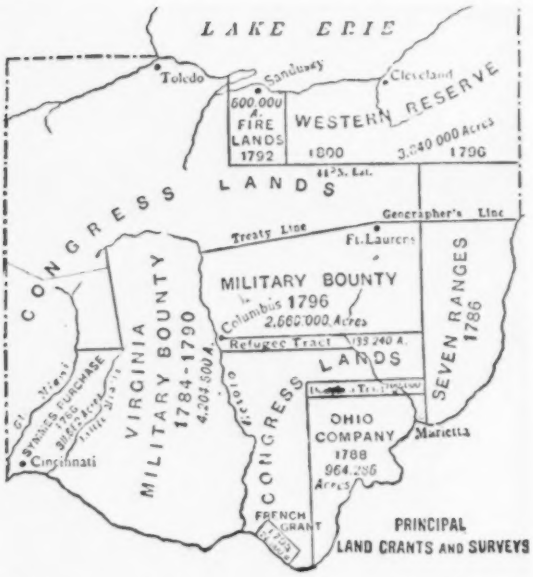


FIG. 1.—Principal land grants and surveys. From Henry Howe: Historical Collections of Ohio, Cincinnati, 1904, Vol. 1, p. 134.

A third element is rectangularity in the pattern of the individual town. The degree of adherence to this form is remarkable in view of the varied physical and civil environment. Briefly, rectangularity is complementary to the other gross features of pattern and is, therefore, common to lands south of the Treaty Line.

ORIGINAL RESERVES[3]

Only two territorial claims of the thirteen states were recognized in Ohio: the Virginia Military District or Bounty and the Connecticut Western Reserve.[4] Only the Virginia tract was occupied before the passage of the land laws of 1785 and 1787, and nowhere else is there the same degree of adherence to this combination of pattern elements.

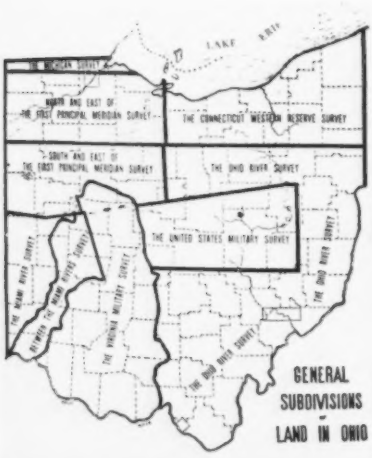


FIG. 2.—General subdivisions of land in Ohio. From W. E. Peters: Ohio Lands, Athens, 1930, p. 83.

London is a typical example. The orientation (see Fig. 3) is definitely other than north-south. Of the 60-odd towns in the Virginia District, 75 per cent are similarly oriented. Another detail of orientation is manifested in the relation of these towns to

[3] Figures 1 and 2 show virtually all the principal grants and original surveys in Ohio. In this paper, for convenience, reference will be made to the principal surveys as shown in Figure 2, rather than to the earlier subdivisions of Figure 1. See map of "Original Land Subdivisions" accompanying Sherman, *op. cit.*

[4] Peters, *op. cit.*, pp. 138 and 234.

the radial system of roads developed throughout the Virginia District. The orientation of the major axis of each town seems to be the result of welding a rectangular pattern of the town on the radial system of roads. Virtually no town shows the characteristics of the ordinary road town.[5]

Where the Virginia District boundary divides a town, as in the case of Bellefontaine (Fig. 4), the persistence of these qualities up to the boundary is striking.

Between the Miamis Survey

This survey in southwestern Ohio followed by one year Ohio's earliest settlement in the southeast. It comprehends the territory between the Miami Rivers northward from the Ohio about a hundred miles. When subdivided, the northern boundary of the Symmes Purchase was the nearest approach to a base line oriented to the cardinal points of the compass. Within the region a third of the towns have north-south orientation, though most of them are riverine. In their relation to the road system there is little resemblance to the towns of the Virginia District or the Ohio River Survey; 15 per cent have the radial setting.

Between this survey and the Indiana line there was a later survey known as the Miami River Survey, the base of which was not the river but the First Principal Meridian. Hence it is not surprising to find two-thirds of the towns oriented in the cardinal direction. Also, their relation to the road system shows but half as many of the radial type as were found between the Miami Rivers.

The patterns of the individual towns in these two surveys likewise differ, but less markedly. Three-fourths of the towns of both tracts are rectangular: in only one other part of the state is that form adhered to so faithfully—the region between these two surveys and the old Lake Plain, north of the Greenville Treaty Line.

Ohio River Survey

Except in the Virginia District, which from the beginning was not under federal supervision, a well defined and simple method of subdivision was arrived at only after many trials. The first application in the United States of the township, or rectangular, plan of subdivision as provided for by the land ordinance of 1785 was made in southeastern Ohio, in a tract known as the Seven Ranges. Ultimately, and with certain modifications, this plan embraced all of Ohio, except, of course, the Virginia District.[6]

[5] Jean Brunhes: Human Geography, translated by T. C. Le Compte, edited by Isaiah Bowman and R. E. Dodge, Chicago and New York, 1920, p. 175.

[6] Peters, *op. cit.*, p. 38.

FIG. 3

FIG. 4

FIG. 3—Vertical aerial view of London, Ohio, showing the pattern associations that characterize the towns of the Virginia Military District—eccentric orientation, rectangularity, and a radial road setting. (The aerial views, Figures 3 to 6, are reproduced by courtesy of the Director of Aeronautics, State of Ohio. The top of the photograph is north.)

FIG. 4—Vertical aerial photograph of Bellefontaine, Ohio, showing a town form in which the western boundary of the Virginia District clearly marks the limits of eccentric orientation.

FIG. 5

FIG. 6

FIG. 5—Urbana, Ohio, a few miles west of London, exhibits the cardinal orientation, rectangularity, and peripheral railroad characteristic of towns in western and north-central Ohio.

FIG. 6—The areal expansion of Franklin, Ohio, has taken place upon the lowland west of the river, since the completion of the Miami Conservancy program in 1918. The canal and railroad occupy the terrace at the right center.

In the Ohio River and the United States Military Surveys of eastern Ohio the impress of this system of survey has been markedly persistent. These regions lie almost wholly within the Allegheny Plateau, and despite the inaccuracies of the pioneer application of the system half of the 130 towns are north-south in orientation. As a concomitant of the relatively high relief, 40 per cent of the towns are accordant with the radial road system.

Sequence of Economies

Transportation was slow and expensive over the best of early roads. Even the change from pack train to freight wagon and stagecoach introduced an era of highway transportation that hastened the economic development of the state. The early development of connected roads was in southern Ohio. This was largely due to the influence of water routes, which played so important a part in early settlement—an influence that was felt up to 1850. Northeastern Ohio was of secondary importance during this period, the northern part of the state being virtually unoccupied. A century later the importance of the two parts as regards highway traffic was reversed.

Canal transportation began in 1825. By 1850 Ohio owned somewhat more than a thousand miles of canals. The Civil War and the following industrial depression marked the beginning of a serious decline of canals as an important part of the state's transportation system.[7]

The railroad came in 1837. During the early period of railroad development and the decline of canals public attention was diverted from road improvement; highways were not restored to their early importance as a transportation factor until the early part of the present century. Officially the state withdrew from active participation in road construction in 1851, not to reënter until 1904.[8]

River Period

The towns of the territory south of the Greenville Treaty Line were established and developed in what may be called, in a confining sense, the River Period. Virtually all of them are riverine; yet only 10 per cent may be said to be riverine in form. No other part of the state shows such a proportion of towns in which the rectangular and riverine forms are welded. Riparian occupance is largely confined to the original bank. As in the Virginia District, the two Miami Surveys, and the Ohio River Survey, there are definite

[7] Report of a Survey of Transportation on the State Highway System of Ohio, U. S. Dept. of Agriculture, Bur. of Public Roads, and the Ohio Dept. of Highways and Public Works, 1927, pp. 13 and 15. See also C. C. Huntington: History of the Ohio Canals, Parts 1 and 3, Ohio State Archaeological and Historical Society, Columbus, Ohio, 1905.

[8] Report of a Survey of Transportation, p. 15.

regional characteristics to the settlement forms arising during the River Period.

The towns on the Great Miami River seem to have undergone the greatest change in form, especially those of the middle and lower valley. Nearly every town in this region was located at a point where the river, which here flows southwest, crossed one of the north-south routes from the Ohio to Lake Erie. All the major tributaries of the Miami enter from the west, thus giving to each focal agglomeration a low river plain on the west. This fact, together with the greater age of the Between the Miamis Survey, has localized cities and towns on the east bank throughout the middle and lower valley.

In the two Miami Surveys and part of the Ohio River Survey a common northern boundary was the Treaty Line. The Virginia District constituted a hiatus, since its greater age had established a different but equally arbitrary northern boundary. Although the Treaty Line serves as an original survey boundary, it has localized no towns or villages and very few roads. This does not seem illogical, since it nowhere served to divide two regions currently open to federal sale. Furthermore, it marked the southern limit of Indian territory and therefore did not enter into the pattern of white occupation.

The mark of river economy is likewise to be noted in the Virginia District and the Ohio River Survey, where riverine location is equally dominant. The towns, especially those of the Virginia District, are more definitely rectangular and less riverine than those in the Miami Valley. In view of the variety of relief features the adherence to the rectangular form is remarkable.

Canal Period

Two main canals constituted the Ohio system. One, the Miami and Erie, a direct waterway between the Ohio River and Lake Erie, closely followed the Great Miami River and utilized its waters. The canal found the generally unoccupied river terrace inviting and appropriated it. No new towns arose to mark its course, though its influence on the economy and the growth of those already established was great.[9] It tended to promote the attenuated form of the agglomeration.

The Ohio and Erie Canal, on the other hand, was designed to serve eastern and central Ohio and pursued a new course throughout much of its length. In both the Cuyahoga basin, in the northeastern part of the state, and the Scioto basin, in the south-central part, the course of the canal was marked by new towns, whose names bespeak their origin—Canal Dover, for example. None of these new canal towns grew to any considerable size. The influence of the canal on Ohio town forms therefore seems to have been slight.

[9] Huntington, *op. cit.*, Part 3.

Railroad Period

Like the canals, the railroads came at a time when the population pattern was fairly well set, except in northwestern Ohio, the only part of the state where the railroad has largely determined town form. Neither the canal nor the railroad essentially modified the town form in 75 per cent of the southern Ohio towns. Nonetheless, the railroad economy has definitely left its imprint on these towns and villages.

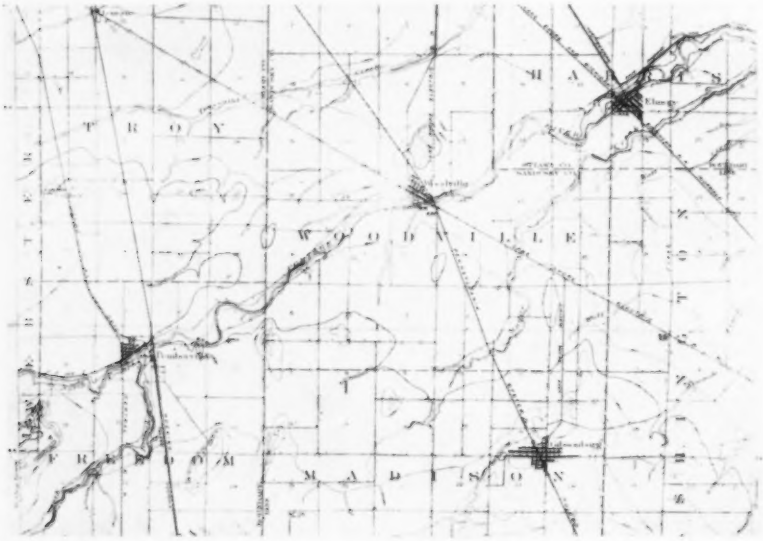


Fig. 7.—The most recently settled portion of Ohio is the old lake plain of the north. Its towns manifest a characteristic railroad dominance. Reduced from U. S. G. S. topographic map, Elmore Quadrangle. Scale approximately three miles to an inch.

In the Ohio River Survey the railroad is peripheral in some 60 per cent of the towns and more or less central in 30 per cent of them; 4 per cent have no railroad. To a greater extent than was observed elsewhere in Ohio, the railroad was the cause of the development of a secondary agglomeration apart from the older town. Most of these secondary agglomerations remained small or were absorbed by the larger town; certain of them, however, reached large proportions and developed more or less independently. Dennison is a railroad-planned-and-oriented town that served the older city of Uhrichsville and has developed as a twin-city urban unit.

The effects of rail economy on town forms in the Virginia District were unlike those in the Ohio River Survey, on the east, or the Miami Surveys, on the west. Although railroads are peripheral in about 80 per cent of the towns of the District, not more than 3 per cent may be said to have been dominated in form by the railroad. The District

lies too far west and south to have the important railroad shops found in eastern and northern Ohio; only its northern and eastern boundaries have localized important interregional lines.

It is especially true of the Miami Valley that the railroad competed with the canal rather than supplemented its services. Railroads found the river terraces inviting; flood hazard did not constitute the insuperable obstacle to rails that it had been to habitation. In fact, it took the railroad to capitalize fully on the river and canal legacies

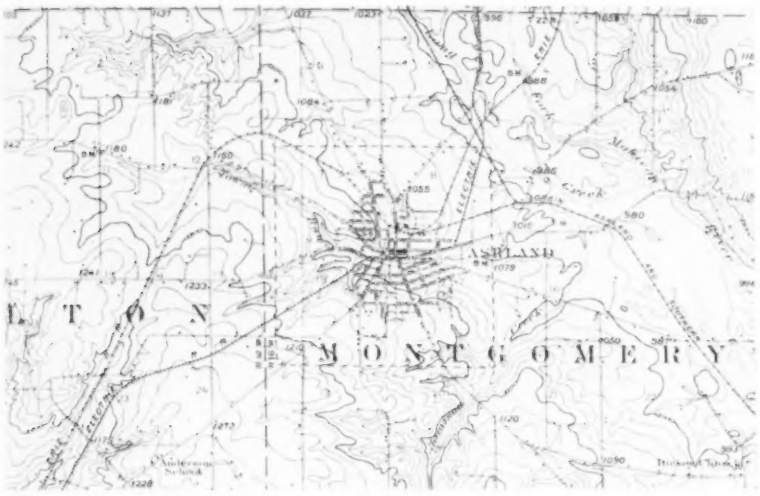


FIG. 8.—Ashland is one of the towns in eastern Ohio the form of which is dominated by the radial system of roads. Reduced from U. S. G. S. topographic map Ashland Quadrangle. Scale approximately one and three-fifths miles to an inch.

to town form. In Figure 6 the close relation between canal and railroad is apparent.

The flood-control program of the Miami Conservancy District, with its attendant changes in land utilization, may be appropriately considered here. Figure 6 illustrates the extent to which the pattern of urban occupance has been modified in a city of the Miami Valley, as flood control permitted urbanization of the adjacent lowlands. In the changed riparian use of urban land, relocation of steam and electric railways, and relocation of highways the pattern of occupance has been altered. It would seem to be no overstatement that complete appraisal of the urban sites in the middle and lower valley was not possible until the flood hazard was overcome.

In northern and northeastern Ohio the railroad came at about the same time as the occupance of the region. Figure 7 shows a section of the Lake Plain in the north in which this means of transportation clearly dominates the pattern of occupance.

Roads

The eccentric orientation of the town forms of the Virginia District at first glance seems to be closely related to the radial system of roads prevailing throughout the District. This relation is more apparent than real; for a closer examination reveals a minimum of road influence on the form of the agglomeration. The road seems to have exercised greater influence on the form of the villages and small towns, though the road town of Brunhes is seldom encountered. The only considerable grouping of this type of agglomeration is along the National Road, the only interregional route of importance in the early decades of the District.

In two parts of Ohio the town forms manifest undeniable influence of the road: the Ohio River Survey, in the south and east, and the Lake Plain portion of the United States Military Survey, in the north. The eccentric orientation of towns in the Ohio River Survey is primarily the result of relief and riverine location rather than of the application of a historical precedent, as in the Virginia District. The eccentricity of orientation is accordant with the radial system of roads, whose influence on town form is pronounced (Fig. 8).

The other part of the state with towns showing marked road influence is the Lake Plain. This poorly drained plain so deterred settlement that it was the last part of Ohio to be occupied. As a result of the reclamation necessary for the construction of highways and habitations, the mile-square system of roads has localized many homes and oriented many of the villages and towns. The old beach ridges of glacial Lake Erie invited occupation because of their superior drainage, and their influence may be detected in certain parts of the central Lake Plain in both the road system and the form of small towns and villages.

RECENT ADVANCES IN MARINE SURVEYING

WORK OF THE UNITED STATES COAST AND GEODETIC SURVEY

A. C. Veatch

THE map, Plate IV, accompanying the following article by Lieutenant Paul A. Smith (facing p. 636) is an excellent example of the type of accurate topographic map of the sea bottom which it is now possible to prepare in areas that have been surveyed by the United States Coast and Geodetic Survey during the past six years. The methods of marine surveying perfected and developed by the Coast and Geodetic Survey during these recent years constitute an outstanding illustration of the astounding rapidity of technologic progress in modern times. They make it possible to prepare contour maps of the ocean bottom, such as the one presented here, of an accuracy exceeding that of many published topographic maps of land areas and comparable in accuracy, so far as the larger features are concerned, with the best of such land maps.

In the period before this recent advance in marine surveying, the data for deeper water were meager and often inaccurate; and although many bathymetric maps were prepared, they represented, for deeper water, little more than the attempts of individuals to deduce the topography of the sea bottom from data of an essentially non-engineering-fact character. Some of these deductions were prophetic, others the reverse. One may recall that, when the project of laying a cable across the Atlantic was under consideration in the middle of the last century, some thirty soundings were made between Newfoundland and Ireland for the purpose of determining the character of the undersea topography that would be traversed by the cable. From these few soundings the eminent geographer M. F. Maury in 1854 deduced the existence of a feature he called the "Telegraphic Plateau" which he assured the cable company seemed to have been specially made for the laying of Atlantic cables. There is no such smooth feature across the Atlantic, as the cable companies subsequently learned, to their great cost, in the repair of cables laid on the irregular bottom.

The more than 5000 accurately located soundings showing the topography delineated on Plate IV were made in a few weeks. In contrast with this, it may be pointed out that the great *Challenger* expedition, in its survey of the oceans of the world extending from 1873 to 1876, made a total of only 504 deep-sea soundings and that the record of the United States Coast and Geodetic Survey's *Blake* under Captain Sigsbee and Captain Bartlett was a total of 3195 deep-sea soundings in its notable work from 1874 to 1879.

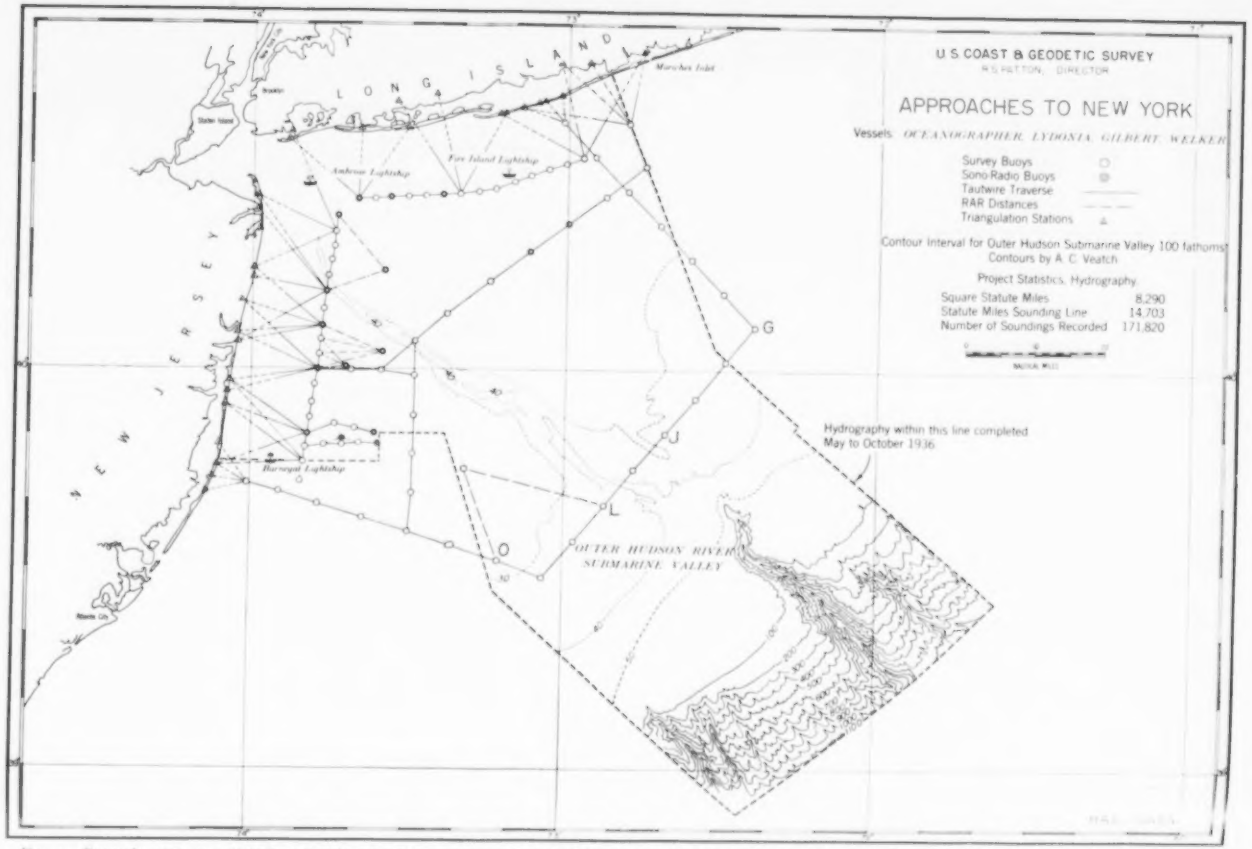


FIG. 1.—Reproduction on a slightly reduced scale of the map on page 157 of Lieutenant Paul A. Smith's article on "Submarine Valleys." *U. S. Coast and Geodetic Survey Field Engineers Bull.* No. 19, 1936, pp. 150–158.—Note that distances on the map are in nautical miles, in the text in statute miles.

Survey off New York Harbor

The speed and accuracy of the present work of the Coast and Geodetic Survey can be well illustrated by its survey of the ocean bottom off New York Harbor in the summer of 1936, during which, in six months, 8290 square miles were surveyed and 171,820 soundings recorded. To afford control for the deep-water survey, 21 survey buoys were placed at intervals about seven miles apart along a line extending southeast from Fire Island, New York, to an outer sector extending southwest and located more than 70 miles from Ambrose Lightship at the outer entrance to New York Harbor and thence a little north of west to Barnegat, New Jersey. For convenience each buoy was designated by a letter. In addition to fixing the positions of the buoys by interbuoy and sun angles, wire-line measurements were made between them with taut-wire apparatus that is in effect "a sea-going tape." The closure error of the traverse of 155 miles made in placing the buoys was $2\frac{1}{4}$ feet to a statute mile. Consequently, when receiving ships were placed at any two buoys, they were at the ends of an accurately measured base line. For part of the seaward survey, receiving ships for radioacoustic ranging were placed at buoys G and L, and thus at two ends of a base line of accurately determined length, more than 40 miles long. For another part of the seaward survey, the receiving ships were anchored at buoys J and O, at the ends of a base line more than 34 miles long. From this line of buoys 70 miles from Ambrose Lightship the survey was extended another 60 miles seaward. The accuracy of this deep-sea work is shown by the fact that a series of sounding lines 60 miles long running seaward from the buoy line in a northwest-southeast direction were cut by a series of sounding lines running east-west. The bottom here is cut by a series of deep canyons (Fig. 1). The topography is rugged, and consequently even slight errors in position at the points of intersection would be reflected in great discrepancies in the soundings recorded. The soundings at the points of intersection checked within negligible limits.

Need for Accurate Maps for Mariners

The primary reason for this seaward work of the Coast and Geodetic Survey is to afford accurate maps for mariners. Fast-moving modern boats are equipped with fathometers, many of them with automatic recorders. Originally used by navigators only in relatively shallow water, they are now increasingly used in deeper water, and maps of the sea bottom accurate as regards engineering thus become of growing importance as aids to navigation. One may envision the day when a fast-moving vessel will be considered not properly equipped unless it has accurate topographic maps of the

sea bottom. The need for maps of this character, which arises from the increase in the size and speed of ocean-going vessels due to advances in the technology of ship construction, has been met by the Coast and Geodetic Survey with corresponding advances in the technology of marine surveying.

The beginning of the Survey was in the days of ships of relatively shallow draft, most of them sailing vessels. Then maps of little more than the coast line and harbors were adequate. Perfection of its technique in the geodetic methods required for accurate shore-line work led to the Survey's being entrusted with the primary-triangulation and precise-level control of the whole country; and the primary triangulation and precise levels of the Survey now afford the basic data for the fundamental horizontal and vertical control of the land maps of this country.

As ships increased in draft and speed, there came a demand for a knowledge of the configuration of the ocean bottom farther and farther from shore, and in course of time a method of surveying areas beyond sight of land was developed by the Coast and Geodetic Survey called "Precise Dead Reckoning" or, abbreviated, "P.D.R." However, at its best P.D.R. could provide no accurate compensation for the variable current and wind drift of the surveying vessels. Even the replacement of the human factor in steering by mechanical devices resulted only in giving a false assurance that the boat was following a straight course. Recent surveys with accurate control show that the line followed by a vessel with a "mechanical mike" set on a given course varies markedly from a straight line because of changing currents and winds. Since the perfection of the new methods and their application and constant improvement by men trained in the exacting demands of primary triangulation and precise levels, the abbreviation P.D.R. has been dubbed "Position Doubtful Reckoning." As an illustration, it may be mentioned that recent work has shown an error in one case of more than 5 miles in the position of a point 50 miles from shore as determined by a P.D.R. line run as late as 1920. This is mentioned not in criticism of the past work but to give a proper perspective of the fundamental difference in the accuracy of the recent deep-water work, extending, for example, in last year's work off New York Harbor more than 125 miles from the shore line, as compared with work under the best-known methods only a decade ago. Improvements devised and perfected by the Coast and Geodetic Survey toward the end of the field season of 1936 have made it possible during the present season to carry accurate control materially farther seaward than was possible last year; and one thus finds the organization and men responsible for the primary-triangulation and precise-level control of the land areas reaching the stage of making comparably accurate surveys far out in the ocean.

New Light on the Physiography of the Ocean Floor

This new work of the Survey, far from land, in giving increasingly abundant deep-water data of an engineering-fact character, affords exact information regarding the physiography of the ocean bottom that promises to upset several time-honored concepts of geologists and to alter many conclusions that have been enunciated in other natural sciences. It marks the opening of an entirely new era of knowledge of the configuration of the ocean bottom.

The color scheme used on the map accompanying Lieutenant Smith's article is the same as that used on the series of four Atlantic coastal-slope charts (Nos. 1313, 1316, 1317, and 1318) now being engraved by the Coast and Geodetic Survey in coöperation with the Geological Society of America, copies of which will be issued within a few months by the Geological Society as illustrations in one of its *Special Papers*. These charts will make available the deep-water surveys made by the Coast and Geodetic Survey on the Atlantic coast by the new methods since 1933 and part of the work of 1931–1932. They will be on a scale of 1 : 120,000 and will show all the soundings and the topography indicated by them. Each of the charts will measure about 34 by 46 inches. Together they will cover the coastal slope from the entrance to Chesapeake Bay to and beyond New York Harbor and, jumping an unsurveyed part, will include one chart of the coastal slope off Georges Bank.

THE SUBMARINE TOPOGRAPHY OF BOGOSLOF

Paul A. Smith

U. S. Coast and Geodetic Survey

[With separate map, Pl. IV, facing p. 636]

BOGOSLOF Island, when viewed from a passing ship, is a small, barren, storm-beaten island in Bering Sea, with precipitous, blue-black cliffs and dark beaches. It is quite otherwise when viewed as a submarine feature, for then the insignificant rocks are seen to be the mere tip of a great submerged volcano. The base of this impressive mountain is some eight miles in diameter; its truncated top is more than a mile in diameter and is covered by a few fathoms of water. The small island—it is about a mile long and less than half a mile wide at the widest part—lies in its center. The true conformation of the volcano and its surroundings was revealed for the first time by the survey made in 1935 by a United States Coast and Geodetic Survey party on the *Discoverer*, under command of Lieutenant Commander H. B. Campbell. The results are presented in Plate IV. The beautifully symmetrical cone is seen towering more than 5000 feet above the northern submerged slope of the Aleutian Archipelago, which is here traversed by a remarkable system of submarine valleys.

Eruption of Bogoslof Volcano

As a surface feature Bogoslof has claimed the attention of explorers and mariners on account of the continual changes it has undergone since the first reported eruption, in 1796. The island has been seen in many different shapes and positions, and different names have been given to its changing features—changing not only as a result of volcanic activity but also through the action of these stormy seas on its crumbling rocks. Davidson gave a chronology of events in the physical history of the island up to and including the notable changes in 1883,[1] and a comprehensive account of it up to 1899 by C. Hart Merriam appeared in the reports of the Harriman Alaska Expedition.[2] The "extraordinary change" during 1906–1907 was portrayed in photographs and sketches and vivid description by T. A. Jaggar.[3] The United States Coast Guard cutter *Tahoma* was on the scene during the violent eruption of 1910, and some striking photographs were

*See preceding paper by A. C. Veatch on "Recent Advances in Marine Surveying," pp. 625-629.

[1] George Davidson: The New Bogosloff Volcano in Bering Sea. *Science*, Vol. 3, 1884, pp. 282-286. See also his paper "Volcanic Eruption in the Bering Sea: The Recent Volcanic Eruption of Bógoslov," *Bull. Amer. Geogr. Soc.*, Vol. 22, 1890, pp. 267-272.

[2] C. H. Merriam: Bogoslof, Our Newest Volcano, *in* Harriman Alaska Ser., Smithsonian Institution, Vol. 2, Washington, 1910 (New York, 1902), pp. 291-336.

[3] T. A. Jaggar, Jr.: The Evolution of Bogoslof Volcano, *Bull. Amer. Geogr. Soc.*, Vol. 40, 1908, pp. 385-400.

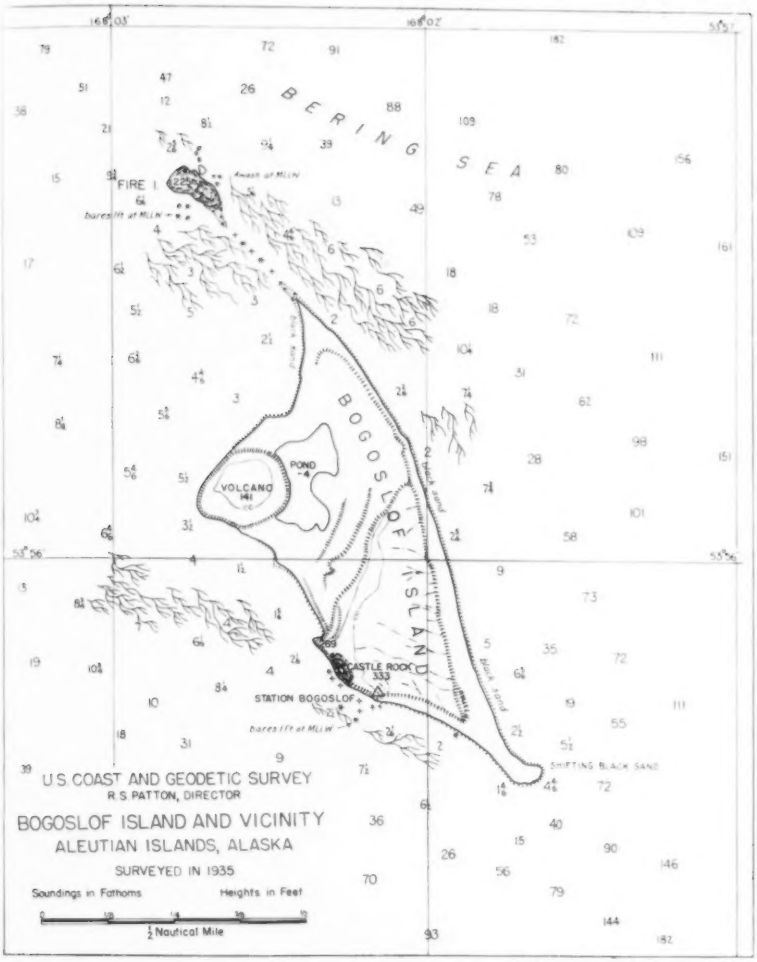


FIG. 1.—Map of Bogoslof in 1935. (Reproduction on a reduced scale of the map on p. 112a of the *U. S. Coast and Geodetic Survey Field Engineers Bull. No. 10.*)

obtained.[4] A sketch map of the island made on this occasion is reproduced in Powers' discussion in the *Geographical Review*.[5]

The present condition and appearance of Bogoslof are described by Lieutenant George E. Morris, Jr.,[6] who made the topographic

[4] R. R. Lukens: Bogoslof Volcano, *Military Engineer*, Vol. 28, 1936, pp. 205–206.

[5] Sidney Powers: Recent Changes in Bogoslof Volcano. *Geogr. Rev.*, Vol. 2, 1916, pp. 218–221.

[6] G. E. Morris, Jr.: Bogoslof Island. *U. S. Coast and Geodetic Survey Field Engineers Bull. No. 10*, 1936, pp. 110–113 (reprinted in the *Alaska Sportsman*, May, 1936, and in the *U. S. Naval Inst. Proc.*, Vol. 63, 1937, pp. 950–952). Following the report (pp. 113–121) is "a reference list of the physiographic history," prepared by Dr. Helen M. Strong and including, in addition to published material, letters, photographs, etc. in the files of the U. S. Coast and Geodetic Survey.

FIG. 2

FIG. 3

FIGS. 2 and 3—Aerial photographs of Bogoslof Island, 1935. (Courtesy of United States Navy.)
Figure 2 is bearing southeastward. Fire Island is in the left foreground; the volcano is the dark mass on the right of the main island. Castle Rock lies beyond.
Figure 3 is bearing southwestward. Castle Rock to left, volcano and pond. Fire Island to right.

survey of Bogoslof in 1935 (Fig. 1) and from whose official report the following quotation is taken:

Bogoslof Island consists of two islands, the main island and Fire Island (first called Grewingk) connected by a rocky bar which bares in spots at mean lower low water. Fire Island resembles a medieval castle which rises nearly perpendicularly from the water. The "mainland" consists of Castle Rock, the Plateau, and the Volcano. Castle Rock (pinnacle rocks) has two summits, sharp in outline rising

FIG. 4

FIG. 5

FIG. 6

FIG. 4—Bogoslof from south-southwest by south, 1935. Castle rock on right, Fire Island on left, active part in center. (Photograph by Lieutenant Commander H. B. Campbell.)

FIG. 5—Fire Island in 1935 when it was 225 feet high. (Photograph by Lieutenant Commander H. B. Campbell.)

FIG. 6—Castle Rock in 1935. (Photograph by Lieutenant Commander H. B. Campbell.)

at the southwestern edge of the plateau. The plateau ends in a vertical cliff along the beach but breaks away in a series of steps to the north. The volcano, a rounded mass of lava, is northwestward of Castle Rock.

Both Fire Island and Castle Rock are beginning to disintegrate and the movements of the nesting fowl start minor rock slides from time to time. The volcano is of more recent formation (reported by the Coast Guard Cutter "Northland" in 1927). It is a mound of porous lava rock or cinders, 140 feet high, that has weathered but little and is still sharp and rough. Steam mixed with a trace of sulphur fumes issues gently from cracks near the top of the volcano. In a few places the rock feels warm to the touch.

The pond at the base of the volcano is salt water with some sulphur in it. The surface is four feet below high water, but a very high tide will cause the pond's surface

to rise about a foot. . . . The surface temperature of the water measured several times during June, July, and August was 68° F. This is several degrees warmer than the sea water and much warmer than the average air temperature. . . . There is a large amount of drift wood scattered along the shore of the pond. This undoubtedly was washed there during an extremely high tide when the water covered the low sand barrier between the pond and the sea.

The plateau of the island is a mixture of black sand, lava dust and cinders, and rock.

The beach is black sand except along the northern spit, where it is pebbles and small boulders, and around the volcano, where it is rocky. The sand is unstable and shifts with the sea. The spit on the southeast end of the island hooks toward the west when the sea has been easterly for a continued period and toward the east when the sea is westerly. . . . The rocky portions of the beach are more stable.

. . . . . .

Bogoslof Island has a local reputation for shifting position rather frequently. This can be accounted for by two reasons other than faulty navigation. Although the island is small it presents a marked difference in appearance when viewed from different directions. Anyone glimpsing the island from different directions on widely separated occasions might believe the island to have changed. The charted positions of the shorelines of Unalaska and Umnak Islands in the vicinity of Bogoslof are in error by a few miles. A navigator taking his departure from different points on Unalaska or Umnak Island would obtain different dead reckoning positions of Bogoslof Island which would create the impression that Bogoslof had shifted in position.

Now that the exact position of Bogoslof Island has been determined for the first time and an accurate record of the topography, surface and submarine, is controlled by the Aleutian Islands triangulation, it will be possible in the future to ascertain definitely the changes that occur after eruptions.

The Hydrographic Survey

The recent hydrographic survey of the ocean bottom around the island was made in connection with the routine charting program of the Coast and Geodetic Survey. It is a good example of the by-product value of modern hydrographic surveys to geophysics. Parenthetically it should be noted that hydrographic surveying methods have been greatly improved in the past decade,[7] largely owing to the ever growing use of echo-sounding devices by merchant and naval vessels. The recent hydrographic survey of the ocean bottom around the island was made by radioacoustic-ranging control and echo sounding. The survey of the Bogoslof area has given enough data to enable one to draw the topography with almost as much certainty as though the features were above water. This has been done in Plate IV.

First a word should be said about the nature of the data from which the topography has been drawn. The hydrographic survey of the area was plotted on a scale of 1:160,000, and more than 5000 soundings were used in the preparation of the map. Sounding lines were run

[7] P. A. Smith: Recent Advances in Hydrographic Surveying, *Civil Engineering*, Vol. 7, 1937, pp. 335-337; *idem:* The Accuracy of Soundings and Positions Obtained by Methods Used in the United States Coast and Geodetic Survey, *Trans. Amer. Geophys. Union, Sixteenth Ann. Meeting, April 25 and 26, 1935*, Washington, 1935, Part 1, pp. 9-14.

by the *Discoverer* in a general northeast-southwest direction and were spaced at intervals of about two nautical miles. As many soundings were plotted on this sheet as the scale of the sheet permitted, that is about three soundings to a mile. A survey on a scale of 1 : 10,000 was made between the shores of Bogoslof Island and about the 300-fathom contour. This large-scale survey, on which many more soundings can be placed, indicates very irregular and broken topography in detail. Sounding lines were spaced about one mile apart between the 300-fathom contour and the 1000-fathom contour in the vicinity of the volcano to develop better the shape of the cone. It should be noted that echo soundings obtained by using a 1000-cycle oscillator do not always reflect the more rugged features, because, as is well known, so low a frequency is not directional. Consequently, steep, submerged canyon walls and precipitous cliffs are modified or "softened," and this effect cannot be completely eliminated by so-called slope corrections because the slope corrections must be computed from the slope of the submerged feature.

Stream Pattern Discovered

It is somewhat of a surprise to discover a definite stream pattern on the ocean floor in this area. The stream pattern is shown on Plate IV in brown, the color chosen after experimentation as most effective for the purpose. This innovation will prove helpful, it is believed, in visualizing submarine topography of this character, now that it can be depicted in detail. The stream pattern is of interest in connection with some of the theories that have been advanced in recent years to explain submarine valleys.[8] The nature of the topography around Bogoslof does not indicate that there has been any faulting since the formation of the volcano or the erosion of the valleys that traverse the surrounding area. The sharp valley with a northwest-southeast trend about 35 miles northeast of the Bogoslof volcanic cone is probably on a fault line with a downthrow to the west of 600 feet or more, as indicated by the topography; and, although some movement may have occurred while the topography was taking shape, there has been no subsequent movement of appreciable magnitude along the line. It would appear that the topographic features now existing on the sea bottom here were formed at some time when the sea was lower, and the topography has been preserved intact by a rising of the sea. Such a rising must have been rather rapid to avoid the erosion and consequent smoothing of the landforms that would result from a slowly rising beach line. Daly[9] has advanced the density-

[8] P. A. Smith: Submarine Valleys. *U. S. Coast and Geodetic Survey Field Engineers' Bull. No. 10*, 1936, pp. 150–158; R. M. Field: Structure of Continents and Ocean Basins, *Journ. Washington Acad. of Sci.*, Vol. 27, 1937, pp. 181–195. F. P. Shepard, who has devoted himself to the problem, outlines it in "Submarine Valleys," *Geogr. Rev.*, Vol. 23, 1933, pp. 77–89.

[9] R. A. Daly: Origin of Submarine "Canyons," *Amer. Journ. of Sci.*, Ser. 5, Vol. 31, 1936, pp. 401–420.

current hypothesis for the formation of submarine valleys that he attributes to Pleistocene time, and his hypothesis has received the enthusiastic support of Kuenen of Leiden and others. Kuenen[10] has made models to illustrate and prove the hypothesis. In these models, and in the hypothesis, a coastal shelf with the loose materials of wave erosion and stream-borne sediments is assumed on which accumulates the muddy water necessary to start the process postulated. In the vicinity of Bogoslof there are no extensive coastal shelves, such as the northern side of the Aleutian Archipelago; yet some remarkable submarine valleys are found there.

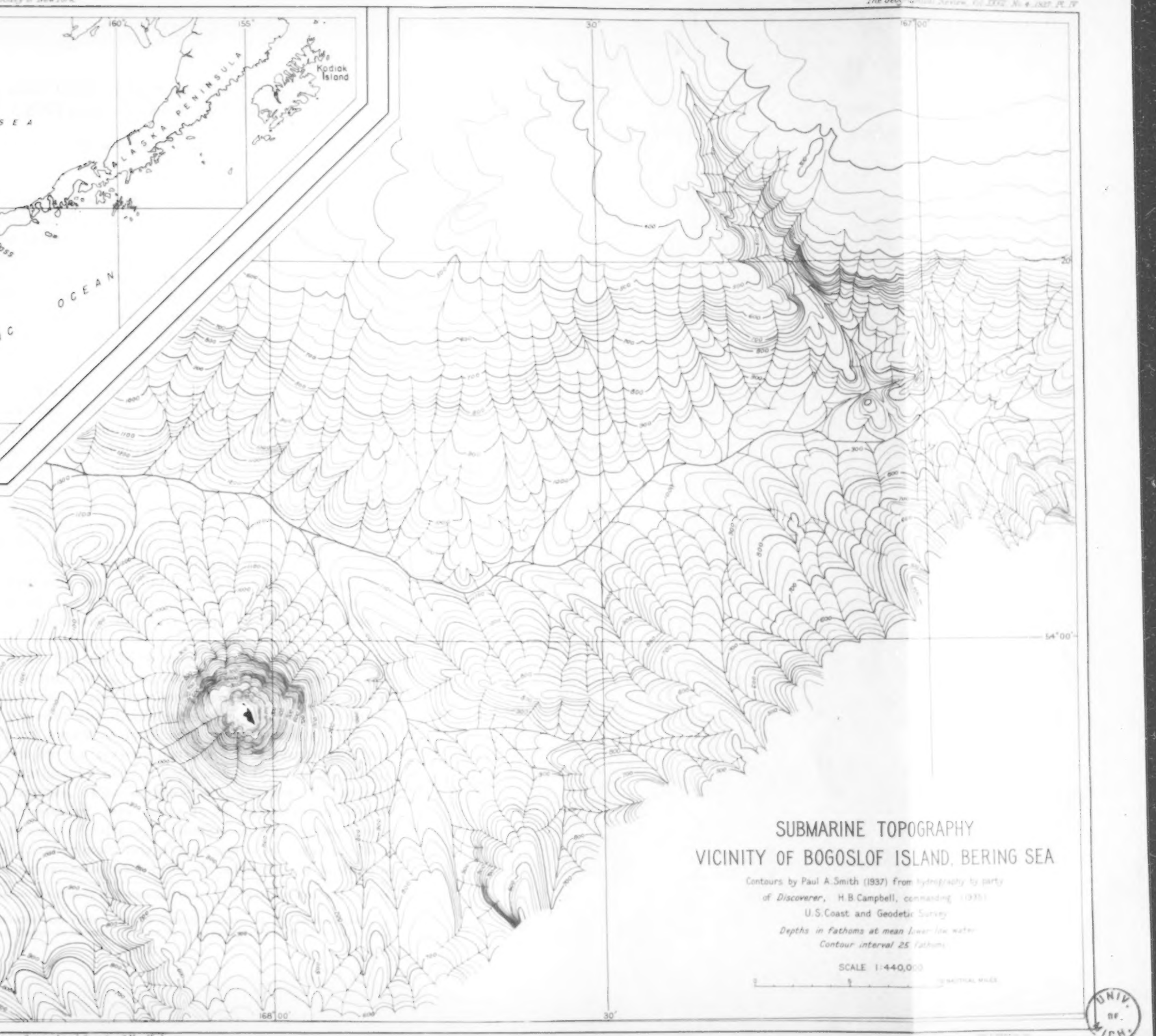
Another distinct feature of the region is the comparatively smooth topography of the submerged coastal slope of Bering Sea north of the large valley north of Bogoslof. This slope, according to the density-current hypothesis, should have the most pronounced valleys, since the entire Bering Sea is a shallow submerged plain, which during the glacial lowering of the seas must have been ideal for the formation of the thick and muddy water necessary to satisfy the hypothesis. The sounding lines on this slope were not all in the most favorable directions to bring out the full relief of the shelf; but it is certain that there are no large valleys similar to those found in the region around the volcano, with the exception of the one obviously controlled by a fault lying northeast of Bogoslof.

A study of the contours of submerged Bogoslof shows the cone to be of the strombolian type, an indication that the volcano was probably built during a time when the sea was at a level lower than the base of the volcano. If the volcano had been formed beneath the waters of the sea, as Jaggar suggested, it would seem that the profile should be different from that of a perfect cinder cone. Just what form it might take if built up by a series of submarine eruptions it is difficult to say. The two valleys northeast and southwest of the submerged mountain were probably controlled by the characteristic downwarping of the sedimentary strata in the vicinity of the initial fissure from which the volcano was born.

Dr. Jaggar's explanation of the *local* changes about the island is undoubtedly correct. However, if the streams were subaerial in origin, the explanation of the formation of the cone under the ocean waters would seem untenable; for if it were correct, the valleys around the base of the mountain, apparently carved by streams that were diverted by the presence of the mountain mass, would have been obliterated by the volcano.

In spite of these additional facts apparently supporting the hypothesis of the lowering of the sea, it must be confessed that the subject is still far from being *res judicata*.

[10] P. H. Kuenen: Experiments in Connection with Daly's Hypothesis on the Formation of Submarine Canyons. *Leidsche Geol. Mededeelingen*, Vol. 8, 1937, pp. 327–351.



SUBMARINE TOPOGRAPHY
VICINITY OF BOGOSLOF ISLAND, BERING SEA

Contours by Paul A. Smith (1937) from hydrography by party of *Discoverer*, H. B. Campbell, commanding (1935)
U. S. Coast and Geodetic Survey
Depths in fathoms at mean lower low water
Contour interval 25 fathoms

SCALE 1:440,000

UNIV. OF MICH.

PREHISTORIC DROUGHTS IN THE CENTRAL GREAT PLAINS

William Van Royen
University of Nebraska

THE recent succession of dry years in the Great Plains and particularly the devastating droughts of 1934 and 1936 have once again focused attention on the fluctuations of precipitation to which our subhumid and semiarid lands in the West are subject. During the first two decades of the twentieth century precipitation in the Great Plains was generally above normal, and this fact in conjunction with the great profits made in wheat farming during the World War tended to obliterate all memory of the drought years of the nineties and other periods of serious moisture deficiency within historical times.

There is little doubt in the minds of students of weather and climate that wide borderland areas between humid and arid regions will always be subject to recurrent droughts of varying duration and intensity, such as those experienced in historical times. Also, before the dawn of recorded history droughts occurred, some of which were brief, others evidently very long.

An increasing volume of evidence points to the occurrence, after the close of the Pleistocene epoch, of several climatic fluctuations of long range and fairly wide amplitude that probably affected most of eastern North America. According to the data available at present, it seems that these long periods, during which average temperature and average precipitation were different from the averages of today, were similar to the periods that have been fairly well established for Europe.[1]

Of these periods, the two driest ones (the Boreal, from 8000 to 5000 B.C.?, and the Sub-Boreal, from 2000 to 600 B.C.?) were probably much drier in the Great Plains than anywhere farther east, assuming, of course, that present regional differences of climate already existed, though possibly in somewhat modified form. Botanical evidence, both that offered by the present distribution of plants and that offered by the stratigraphy of peat bogs, seems to favor such long-range climatic changes. Physiographic evidence also, if carefully evaluated and interpreted, may prove to be an important aid in studying this problem. Ellsworth Huntington and others[2] have drawn attention to the climatic origin of certain river terraces. Morphologically young terraces bearing all the earmarks of a climatic

[1] See W. Van Royen: The Problem of Postglacial Climate, *Bull. Amer. Meteorol. Soc.*, Vol. 17, 1936, pp. 246–251.

[2] Ellsworth Huntington, with contributions by Charles Schuchert, A. E. Douglass, and C. J. Kullmer: The Climatic Factor, as Illustrated in Arid America, *Carnegie Instn. Publ. No. 192*, 1914.

origin exist over much of the central Great Plains and are especially pronounced in some parts of the northern High Plains. I have studied the terraces along many streams in western Nebraska, eastern Wyoming, and the neighboring parts of Colorado, and I expect to show later that the youngest of these terraces can be explained better on the basis of post-Pleistocene climatic changes than on that of tectonic movements of an epeirogenetic nature.

Besides these long-range changes of climate, probabilities are heavily in favor of the repeated occurrence of protracted periods of subnormal precipitation of much shorter duration, ranging from relatively brief ones, such as, very likely, the present drought and those of the nineties, the sixties, and the thirties, to those lasting several decades, such as the well known great Pueblo drought of 1276 to 1299.

Many of these droughts were undoubtedly too brief to leave permanent and easily discernible traces in the landscape. Those of longer duration, however, may have left their imprint in isolated, favored spots. Douglass' remarkable chronology has shown the occurrence of several severe prehistoric droughts in the Southwest. Archeological excavations of prehistoric and protohistoric Indian sites in the central Great Plains by W. D. Strong, E. H. Bell, A. T. Hill, W. R. Wedel,[3] and others have offered an excellent opportunity to study many minor and relatively recent physiographic changes, and coöperation in the field with these archeologists has resulted in the accumulation of some interesting data that to a certain extent seem to corroborate the findings of Douglass in the Southwest. From the steadily increasing quantity of available data I propose to discuss in some detail the so-called Lynch site, excavated by Bell, and the Signal Butte site, excavated by Strong.

The Lynch Site

The Lynch site is near the town of Lynch, in northern Nebraska, about ten miles south of the point of contact between the northern boundary of Nebraska, which follows the 43rd parallel, and the Missouri River. Lynch is on Ponca Creek, a small tributary of the Missouri, which has its source in South Dakota and enters the main stream just above the Niobrara. The site is on what has been called

[3] A. T. Hill: Ruins of Prehistoric House in Howard County, *Nebraska History Mag.*, Vol. 13, 1932, pp. 172–175; W. R. Wedel: Reports on Field Work by the Archaeological Survey of the Nebraska State Historical Society, May 1 to July 23, 1934, *ibid.*, Vol. 15, 1934, pp. 132–255; E. H. Bell and William Van Royen: An Evaluation of Recent Nebraska Finds Sometimes Attributed to the Pleistocene, *Wisconsin Archeologist*, Vol. 13 (N.S.), 1934, pp. 49–70; W. D. Strong: An Introduction to Nebraska Archeology, *Smithsonian Misc. Colls.*, Vol. 93, No. 10, Washington, 1935; A. T. Hill and W. R. Wedel: Excavations at the Leary Indian Village and Burial Site, Richardson County, Nebraska, *Nebraska History Mag.*, Vol. 17, 1936, pp. 3–73; W. R. Wedel: An Introduction to Pawnee Archeology, *Bur. of Amer. Ethnology Bull. 112*, Smithsonian Instn., Washington, 1936; E. H. Bell: Chapters in Nebraska Archaeology, Vol. 1, University of Nebraska, 1936.

by G. E. Condra[4] the Northern Tableland and well in the Boyd Plain subdivision, which is developed on Pierre shales. This region is separated by the Holt, Ainsworth, and Crookston-Springview Tablelands from the great Nebraska Sandhill Region and is too far from the sand hills for any direct physiographic relationships to exist. This is important; for in the Sandhill Region it is difficult to evaluate the

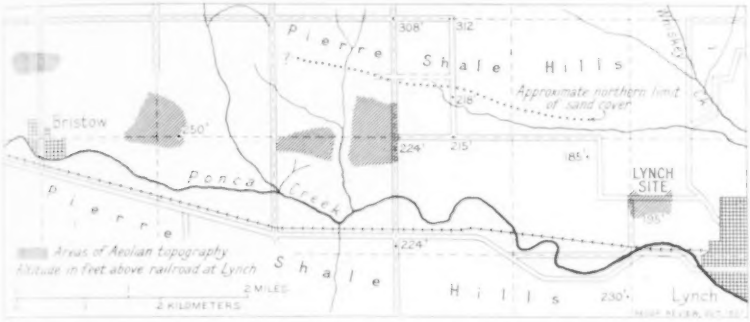


FIG. 1.—Sketch map of general neighborhood of the Lynch site, and areas of eolian topography.

probable age of many minor landforms, since recent changes have been more numerous and extensive on account of local destruction of the protective vegetative cover by man and beast and of the large quantities of eolian material thus liberated for redeposition.

Both north and south of Ponca Creek the gently rounded hills and flat, tablelike expanses of the upland consist of Pierre shales, which also produced the clayey soils of this region. Sands are not found, except near Ponca Creek. The valley of this creek, at some time during the Pleistocene, was evidently gradually dammed up at the lower end, since deposits of sands with coarse to medium gravels were succeeded first by coarse, light-yellow cross-bedded sands and finally by somewhat darker yellow and slightly finer sands. Subsequent erosion of Ponca Creek has left part of these sands as high terraces on each side of the valley (Fig. 2). On the south side the remnants are only fragmentary, but on the north side they form a well developed and fairly extensive level at about 200 to 250 feet above the present flood plain. This terrace is dissected by some of the larger tributaries to Ponca Creek, such as Whiskey Creek (Fig. 1), and by several short, deep gullies or sand draws in the terrace front (Fig. 6). Just west of Lynch the terrace is separated from the Pierre-shale hills to the north by an eastward-flowing tributary to Whiskey Creek.

The excavations of the University of Nebraska Archaeological Survey, directed by Dr. E. H. Bell, are a short distance northwest of

[4] State geologist, Nebraska Geological Survey.

Lynch (Figs. 3 and 6) on what is locally the highest point of the dissected terrace between Ponca Creek and the small stream to the north. The entire site is of considerable extent and covers an area on the terrace about three miles from west to east.

Two main trenches were dug, S1 and S3 (Figs. 4 and 6), disclosing a thick, dark culture stratum, which near the ends of the trenches

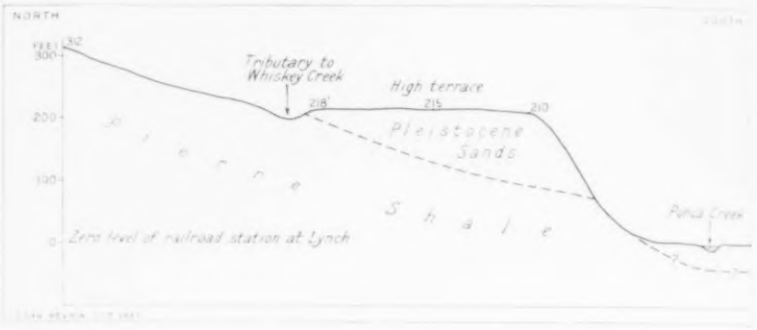


FIG. 2—Cross section of high terrace west of the Lynch site.

was found to lie about a foot below the surface and which was covered near the center by eight feet of sand. In the hill to the southeast (Fig. 6B) the culture stratum was found by means of a boring at a depth of about 15 feet. To the south the site is limited by the steep terrace front; to the north conditions become less distinct because of a wide west-east road and, beyond this, a cultivated field.

The excavation is in an area of prairie that has never been disturbed by the plow. Although just north of the trenches the culture stratum lies at a very moderate depth and in the fields beyond the road has even been exposed and partly destroyed by plowing and wind erosion, at the site of the trenches and to the southeast this stratum is covered by two low dunes (Fig. 6 A and B). The excavations reveal from top to bottom, first, 1 foot to 1½ feet of sandy material colored gray by plant matter; next, as much as 6½ feet of clean, sterile yellow sand; and, last, the culture stratum, from 1 inch to 26 inches thick, colored dark by cultural debris and bearing all the earmarks of an old soil horizon (Fig. 5). Toward the north end of the east trench, under an overburden of about 3 feet of sand, cultural detritus was lacking over a stretch of 10 to 15 feet. Here the old soil horizon showed distinctly. The presence of these recent sand accumulations on what is locally the highest point of the terrace pleads against water deposition, and a detailed study of the trenches has confirmed that view. The coarsest sand particles were not more than a few millimeters in diameter, and these larger ones were sparse. The contact between the top of the culture stratum and the barren sand is irregular and points to

FIG. 3—View from south side of Ponca Creek Valley towards the high terrace north of the river. The excavations are barely visible on the horizon (middle of picture).

wind rather than to water action. The slight depressions of the culture horizon were filled, not with water-laid, dark-colored material derived from the adjacent higher parts of the culture stratum, as would be expected in the case of action by water, but with clean and evidently wind-borne sand. The presence of clean, light-colored sand in the top part of the culture horizon seems to point to increasing wind activity toward the close of the period of occupancy. After the trenches had been exposed to the wind for several weeks, an indistinct but fairly regular stratification of the sand became apparent. This stratification corresponded better to what one would expect in a low sand accumulation caused by wind rather than in a deposit laid down by water.[5]

There is no room for doubt that the sand is wind-laid. Even at present this area is one of strong winds, which blow mostly from the northwest. A 24-year record of observations indicates that at Lynch the prevailing winds are northwest during 9 months out of 12, and a record of equal length gives the same

FIG. 4—Looking north from about the middle of the east trench (S_3), Lynch site.

[5] In support of the fluviatile origin of the sand a visiting geologist pointed out the presence of "mud balls" in the beautifully smoothed walls of the trenches. These "mud balls," however, turned out to be cross sections through old rodent holes.

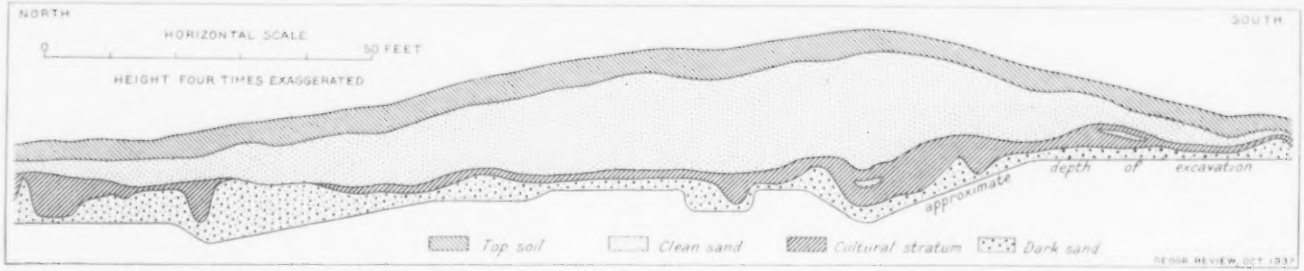


FIG. 5

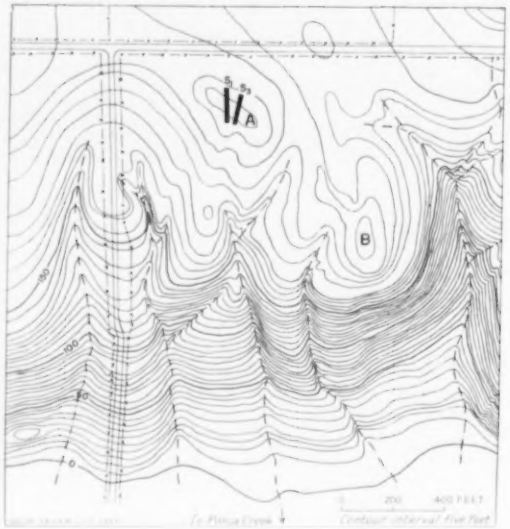


FIG. 6

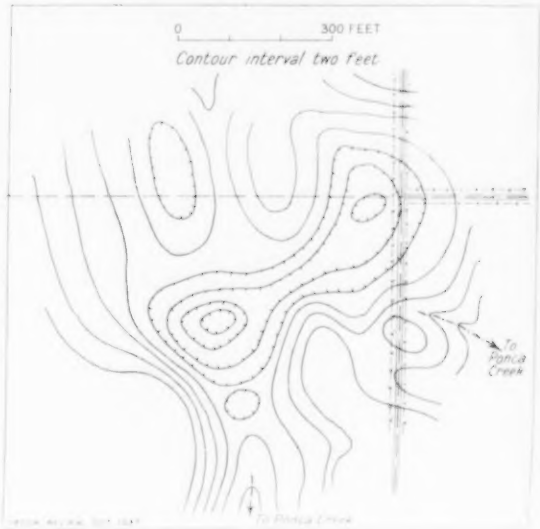


FIG. 7

FIG. 5.—Cross section at the Lynch site. Along the west wall of the east trench (See on Figure 6).
FIG. 6.—Topographic map of part of the Lynch site, showing high terrace, terrace front, and flood plain of Ponca Creek. (Courtesy of University of Nebraska Archeological Survey.)

results for the neighboring town of Butte.[6] This sand was not blown out of the present flood plain, which is 200 feet below the terrace, is well covered with vegetation, and lies against the direction of the prevailing winds, but was derived from the old, water-laid Pleistocene sands of the high terrace on which the sand accumulations are located.

Further exploration of the general neighborhood revealed, farther west on the same terrace, several other areas of low eolian topography, strongly resembling that of the site (Fig. 1). One of these areas was mapped in detail, and the topography leaves no doubt of its origin (Fig. 7). A boring in one of the lowest isolated sand accumulations near by (4 feet high) revealed the existence of a dark horizon, an old soil zone, at a depth of 4½ feet. Thus it is seen that conditions at the site are not entirely local but are encountered over most of the terrace. In the Pierre-shale uplands no sand accumulations were found.

From the foregoing it is evident that after the occupation of the site there must have been a period during which sand was blowing all over the high terrace and forming the low hills and little hollows mentioned above. Can this have taken place during the white man's occupation of the area?

This part of Nebraska once belonged to Dakota Territory and was occupied almost entirely by a Ponca Indian reservation, a Sioux reservation, and the Fort Randall military reservation. During this time it was closed to white agricultural settlers. It was joined to Nebraska in 1882, but the Indian titles were not extinguished until the fall of 1890. The following spring it was organized into a separate county, Boyd County. According to available information, white occupation did not start until then. Thus the plowing up of some of the land cannot have been begun more than about 45 years ago, and many parts were plowed up much more recently than that.

At present some sand blows from plowed lands north of the Lynch site and in some other places on the terrace, but nowhere have I observed any signs of active accumulation of sand dunes, except for some small deposits along fences and in ditches. There is hardly any blowing from grasslands. Present wind activity cannot possibly account for the quantity of sand in the areas of low dune topography mentioned above. Besides, it is impossible that 12 to 18 inches of topsoil, which was found at the site, could have formed in a few decades. Hence the formation of these eolian-sand areas, most of which have never been plowed and are still covered with poor to good stands of native grass, must predate the white man. Even today, after the recent series of dry years, the stands of grass, especially where no overgrazing has taken place, are surprisingly good. Before the arrival of the white man, with his plows and his cattle, a good grass cover of

[6] Climatic Summary of the United States, . . . to 1930, Inclusive, Section 39, Eastern Nebraska, U. S. Weather Bureau, Climatological Division, 1932.

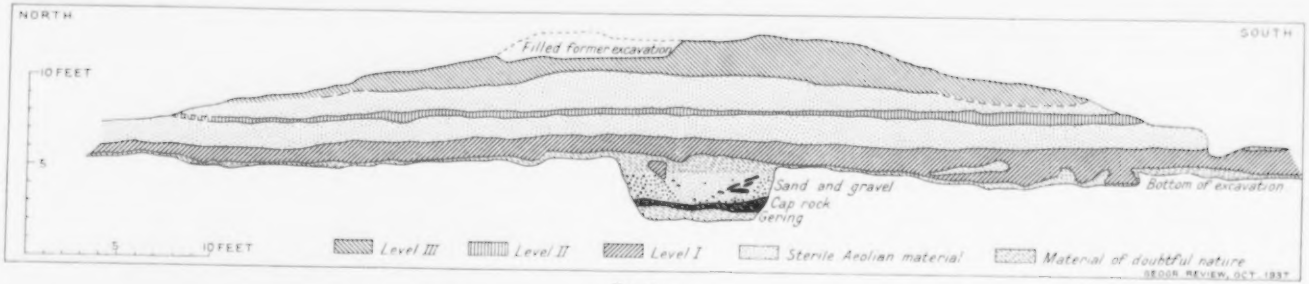


FIG. 8

FIG. 9

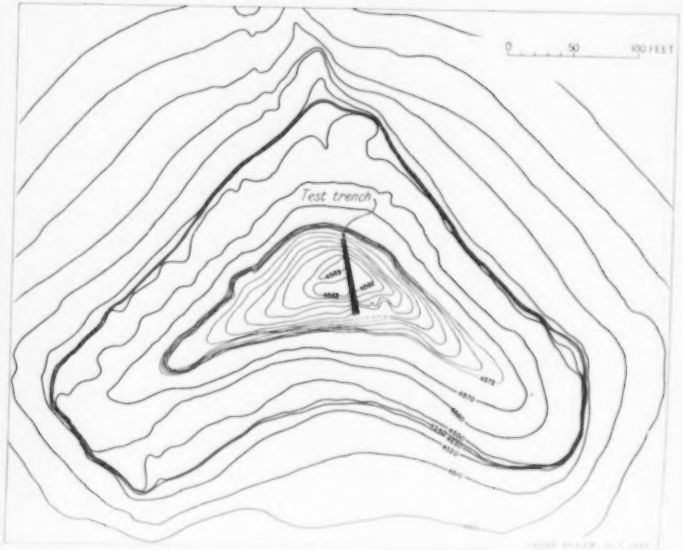


FIG. 10

FIG. 8.—Cross section through center of earth cap on top of Signal Butte, Nebraska. (Courtesy of W. D. Strong, Smithsonian Institution.)
FIG. 9.—Signal Butte, a small outlier of Wild cat Range in western Nebraska.

mid and short grasses existed all over this area. Consequently, before extensive wind work could take place a protracted drought would first have had to thin the vegetation, so that open spaces formed between the separate plants or groups of plants. Then the drought would have had to last long enough to destroy most of the remaining dense network of roots under these open spaces. Neither the stock argument of trampling of the sod by buffalo herds nor that of recurrent prairie fires is adequate to explain the topographic changes. In the light of present conditions a severe drought 25 years long seems hardly sufficient to account for the amount of wind work observed.

The Case of Signal Butte

The case of Signal Butte resembles that of Lynch in several respects, but it differs in others. The Signal Butte site was excavated in 1932 by Dr. W. D. Strong, and I visited it many times before, during, and after the excavations.

Signal Butte (Fig. 9) is a small outlier of Wildcat Range, in western Nebraska near the Wyoming border. Wildcat Range itself is a large outlier of the Cheyenne Tableland, from which it is separated by Pumpkin Creek Valley. The tableland and outliers consist of practically horizontal Tertiary sediments, from the sandy Brule clay at the base, through Gering and Arikaree sandstones, to the Ogallala at the top. The butte itself is made up of a Brule-clay base on which lies a thick stratum of Gering sandstone with nearly vertical walls. The top part, probably Gering, consists of a hard cap rock, two feet thick. Above this partly broken cap rock lies a bed of sand, about two feet thick, enclosing pebbles from the Gering underneath. This sand, which bears all the earmarks of residual mantle-rock, grades into a thin silt deposit, the origin of which is still in doubt. Above the silt is two to eight feet of very fine sandy to silty material, undoubtedly eolian; this material is divided at intervals by three horizons of human, cultural debris, representing old living levels (Fig. 8).

The lowest level (the levels are numbered I to III from bottom to top) lies directly on the silt, and its material is of eolian origin. It is "impregnated with artificial matter, and contains humus to the extent that the horizon presents a sooty blackness. Some blackness may be attributable to burning, but a soil horizon is undoubtedly present."[7] Level I and probably part of the material underneath represent a period of wind activity followed by a more humid period, during which a soil formed and during part of which the butte was occupied by Indian hunters. Strong mentions the fact that this stratum is highly cemented by calcium carbonate and some of the animal bones left by the early occupants are partly mineralized.

[7] Strong, *op. cit.*, p. 227.

This enrichment by calcium carbonate probably took place during and after the further accumulation of eolian material. The faunal material investigated by C. L. Gazin and G. S. Miller seems to indicate a post-Pleistocene age of the culture horizon.

> Above level I lies a 1½-foot horizon of sterile wind-borne material. Occupation of level I must have ended abruptly, as shown by the sharp transition into the sterile layer above. Above this sterile layer is a thin dark horizon (level II) about 6 inches thick. This horizon is darker than the sterile layers above and below, and it contains small amounts of rocks, bones, artifacts, and a few fireplaces. Level II is capped in the center by about 2 feet of sterile wind-borne material, and this in turn is covered by about 1½ feet of soil containing artificial matter (level III). At the surface a vigorous growth of prairie grasses has darkened the soil to a depth of 3 or 4 inches.[8]

The two layers of sterile sand represent dry periods, during which eolian accumulation was active. The middle cultural level (II) evidently was not exposed long enough to make possible the formation of a distinct soil; but the 3 or 4 inches of darkened material just below the present surface indicates a considerable lapse of time to permit the accumulation of this plant matter. (For the sake of comparison it may be stated here that the present average annual precipitation at Lynch is 24 inches, that in the Signal Butte region about 16 inches.) There is no doubt that practically the entire earth cap on Signal Butte is due to eolian accumulation.

Both theoretical considerations and the experience of Strong's field party while working on the butte point to an upward deflection of the wind and the creation of eddies of comparative quiet on the top itself.[9] Furthermore, the form of the earth cap before excavation was begun distinctly showed it to be determined by wind action (Fig. 10). The gentler slope to the northwest and the steeper slope to the southeast point to the prevalence and greater velocity of northwest winds. This corresponds to present wind conditions. A 12-year record shows prevailing northwest and west winds throughout the year at Mitchell, Neb. Although local topography may be partly the cause of the prevalence of northwest winds at Mitchell, its nearness to the butte suggests similar conditions there. Grazing land prevails around Signal Butte, but there are many cultivated fields farther to the west and north. On windy days some soil blows from plowed fields in this general area, but no active accumulation seems to be taking place on or near the butte. The sod of the grazing land is still in fairly good condition, though here and there patches of bare Brule clay are visible. These are small, however, and are not of much

[8] *Ibid.*

[9] This movement is well illustrated by a study by F. Ahlborn of the air currents over the island of Helgoland: see V. Conrad: Die klimatologischen Elemente und ihre Abhängigkeit von terrestrischen Einflüssen (Handbuch der Klimatologie, edited by W. Köppen and R. Geiger, Vol. 1, Part B), Berlin, 1936, Fig. 81 (p. 307).

importance as sources for wind-blown material, which in this area is largely furnished by tilled fields.

In the upper sod and on the surface of Signal Butte a few trade objects were found, but even the highest level (III) contains cultural material, especially pottery, much of it similar to that of certain prehistoric upper-Republican sites, the age of which is estimated by archeologists at about 500 years. Hence the accumulation of eolian material on the butte must practically all have taken place before the advent of the white man. Only a much thinner cover of native vegetation than that existing at present in the area would have permitted opportunity enough for active wind work.

Levels I and II do not contain any pottery whatsoever and thus may be considerably older than level III. The sterile strata between I and II and II and III indicate dry periods, during which the butte was not occupied. Here we have further evidence of periods of eolian accumulation, indicating much severer and much more prolonged droughts than are known in historical times in this area.

When did these droughts occur, and how long did they last?

Occurrence and Duration of the Droughts

In the case of the Lynch site it is highly probable, as was pointed out above, that the sand accumulation immediately followed, and was even partly contemporaneous with, the occupation of the site. The culture stratum does not show any influence of the white man, i.e. the site is archeologically prehistoric, since it predates even the indirect influence of the whites. Among the cultural materials found here there are, however, fragments of pottery closely resembling the so-called Oneota pottery. If this identification should prove to be correct and if all the other material discovered should corroborate this, the Lynch site may be fairly late prehistoric. If, on the other hand, the cultural remains should belong to a different category, the site may very well date back many more centuries. From the geographer's point of view a comparatively youthful age of this site would be interesting and instructive, since it would bring a period of very severe drought much closer to the time of the first occupation of this area by the white man than we have heretofore suspected. It would also indicate a much more rapid formation of soils in the central Great Plains than is generally accepted.

The tree-ring chronology of Douglass has proved the occurrence of a catastrophic drought in the Pueblo region from 1276 to 1299 and another, less severe one from 1573 to 1593,[10] besides several others as far back as about A.D. 800.

[10] A. E. Douglass: Dating Pueblo Bonito and Other Ruins of the Southwest, *Natl. Geogr. Soc. Contributed Technical Papers, Pueblo Bonito Ser. No. 1*, Washington, 1935.

Can the droughts in the central Great Plains be correlated with those in the Southwest?

The chance seems to be against such a possibility. In the first place, although *Pinus ponderosa*, on which Douglass worked in Arizona, grows in parts of western Nebraska, very little wood of the kinds used by the Indians in construction and for the manufacture of implements has survived in the Great Plains. Hence the only material of any promise would be fairly large pieces of charcoal. None of any importance have been discovered to date.

In the second place, it is doubtful whether the relatively recent and short droughts of Douglass' Southwestern chronology, such as the two in the Pueblo region, were necessarily contemporaneous with droughts in the central Great Plains. The drought of about 1890 to 1898 in the central Great Plains was nearly contemporaneous with that of 1896 to 1904 in the Pueblo region. On the other hand, the most recent family of droughts in the central Great Plains from 1930 to 1936 shows little relationship to the Southwest. In fact, a decidedly opposite trend in some years is indicated, as in 1930, 1931, and 1936. Still, one might wonder whether a period of subnormal precipitation in the central Great Plains lasting, for example, half a century could have been so localized as not to have affected the region just west of a mountain belt of no particularly great relative altitude. The principal difficulty is that, whereas meteorological records for the entire area generally do not go back more than 50 years (a few scattered stations have slightly longer records), time, as we are dealing with it here, is to be counted in centuries.

Finally, even if correlation should be possible, it is doubtful whether the two main droughts of Douglass' record (1276–1299; 1573–1593) would fit the cases. On the basis of cultural evidence presented by Strong neither of these droughts could apply to Signal Butte, unless the indistinct level II is much younger than is now apparent. They might be considered for the Lynch site, however. The later of the two seems to be improbable because of the clearly prehistoric aspect of the Lynch culture, and an objection to both is their rather short duration. Twenty to twenty-five years of drought would hardly suffice for the topographic changes noted near Lynch in an area where the present precipitation is about double that of the Southwest.[11]

In the case of Signal Butte, archeological evidence, such as the total absence of pottery in levels I and II, and some points of resemblance between artifacts from level I and those of the near-by Spring Creek quarry, where an extinct species of bison was found, indicate a respectable age for at least the lowest level and probably also the middle one. To attempt correlation with the postglacial climatic fluctuations established for Europe and made likely for North

[11] Lynch, 23.9 inches; Butte, 22.3; Pueblo region, from less than 10 inches to 15

America also is therefore quite warranted, though we must keep in mind that the postglacial chronology in North America is still so uncertain that it is necessary to beware of placing too much reliance on what at present can be only provisional dates.[12]

Strong bases the age of the Signal Butte eolian deposits partly on evidence from a sand-dune area southwest of the butte. These dunes should have migrated from the present channel of the North Platte River, 14 to 18 miles away, to their present position. This distance divided by the average annual rate of movement of sand dunes would give some indication as to the time elapsed since these dunes, and also the eolian cap on Signal Butte, were formed. But even such a method of approximation is full of pitfalls. In the first place, the present dunes in this area, where not disturbed by road building, trails, or trampling of cattle around a stock well, are all fixed by vegetation. How long they have been so, we do not know. In the second place, from my study of sand dunes in this general region it does not appear necessary at all that these dunes should have originated in the present channel of the Platte. Sandy Pleistocene terrace deposits and sandy bedrock abound in this area. In fact, the dunes lie, according to Darton, in an old Pleistocene Platte channel.

Unfortunately, no peat deposits containing pollen sufficiently well preserved for study of the pollen profile have thus far been discovered in this part of Nebraska and Wyoming. However, such discoveries may yet be made. Also, an investigation of peat deposits in Iowa might permit more dependable conclusions regarding long-range climatic fluctuations during the postglacial in the territory farther west. All things considered, it is not improbable that one or both of the sterile strata on Signal Butte may correspond to a long dry period from three to four thousand years ago or that they may be even older.

Even if accurate dating of these eolian deposits is at present impossible, it is certain that in both the Signal Butte site and the Lynch site we have definite evidence of prolonged and severe prehistoric droughts. These droughts, in the light of present conditions, must have been both longer and drier than any of the droughts of historical times.

Droughts Inevitable

The old Great Plains adage that rain follows the plow has long been recognized as merely an example of the wishful thinking of farmers or of willful misrepresentation by land speculators. The subhumid to semiarid parts of the Plains have always been subject

[12] See, for example, F. E. Clements and R. W. Chaney: Environment and Life in the Great Plains, *Carnegie Instn. Suppl. Publs. No. 24*, 1936.

to climatic fluctuations, especially fluctuations of precipitation of varying intensity and varying duration, from short and relatively harmless ones to long and catastrophic ones. As long as man is powerless to change the climate, this condition will prevail.

Of decidedly cyclical movements there is yet no clear evidence,[13] and forecasting of droughts remains a hazardous undertaking. Hence it is doubly necessary that man take cognizance of these vagaries of nature and base his activities in the central Great Plains, especially in its western part, on the fact that fluctuations of precipitation will continue to occur. It is only human nature that, when the present (or recent?) series of dry years shall be followed by another period of above-normal precipitation, warnings of the past are likely to be forgotten in the face of immediate profits to be obtained. In the long run, such a happy-go-lucky policy will inevitably lead to disastrous results for the people occupying the land, as well as for the land itself.

[13] See footnote 12. See also D. Brunt: Climatic Cycles, and discussion, *Geogr. Journ.*, Vol. 89, 1937, pp. 214–238.

SOUTH AFRICAN COASTAL WATERS IN RELATION TO OCEAN CURRENTS*

William Edwyn Isaac

IT has long been known that the coasts of South Africa are subject to the influence of warm and cold ocean currents, the former along the east and south coasts, the latter along the west coast. From the navigator's point of view much information exists concerning the warm current; but data relating to the influence of both the warm and the cold currents on the coastal waters of South Africa are meager and scattered. A popular view that the Cape of Good Hope marks the division of the currents is incorrect both in that most of the warm-current water does not extend so far and in the over-simplification of a somewhat complicated current system.

The direction of the currents round the coast is affected more by the margin of the continental shelf than by the coast line itself. The limit of the continental shelf in Africa is not far from the coast line for most of its extent. In the region of Cape Agulhas, the southernmost point of the continent, there is, however, an extensive area of shallow water, known as the Agulhas Bank.

The map shown in Figure 1—reduced from the British Admiralty chart of the Indian Ocean in current use, which itself is based on a chart drawn up by Rear Admiral Richards in 1870—indicates 115 miles as the maximum extent of the Agulhas Bank beyond the limits of the land. At the longitude of Cape Agulhas the bank extends southwards for about 80 miles. On the map the limits of the bank are left indefinite; but for the purposes of navigation it is regarded as tapering off much more to the west than the chart suggests. For practical purposes its eastern limit may be placed in the region of Knysna.[1] The existence and extent of the Agulhas Bank have been recognized since early times, as is evidenced by Blaeu's map of "Æthiopia Inferior" published about 1650, in which the bank is represented with tolerable accuracy. It also appears on Hondius' map of 1606, on which, however, it is shown as of very small proportions.

Coastal Waters Influenced by the Agulhas Current

About 11° south of the equator, in the region of Cape Delgado, a branch of the current system of the Indian Ocean divides into two,

*I have pleasure in thanking Captain England (former port captain, Capetown) for his interest and help; also Captain Weller, the present port captain at Capetown, and Dr. C. von Bonde, director, Fisheries and Marine Biological Survey of South Africa. The work was done in the Botanical Department of the University of Capetown. To Professor R. S. Adamson of that department and to Mr. G. E. R. Deacon of the *Discovery II* I am indebted for criticizing the manuscript.

[1] This suggestion is made on the authority of Captain England.

one branch flowing northwards and the other—the Mozambique Current—flowing southwards along the east coast of Africa, where it is joined at about Delagoa Bay by a southwest branch of the South Equatorial Current.[2] The confluence of the two streams forms the well known Agulhas Current, which follows the general direction of the coast line until, reaching the Agulhas Bank, it tends to follow the

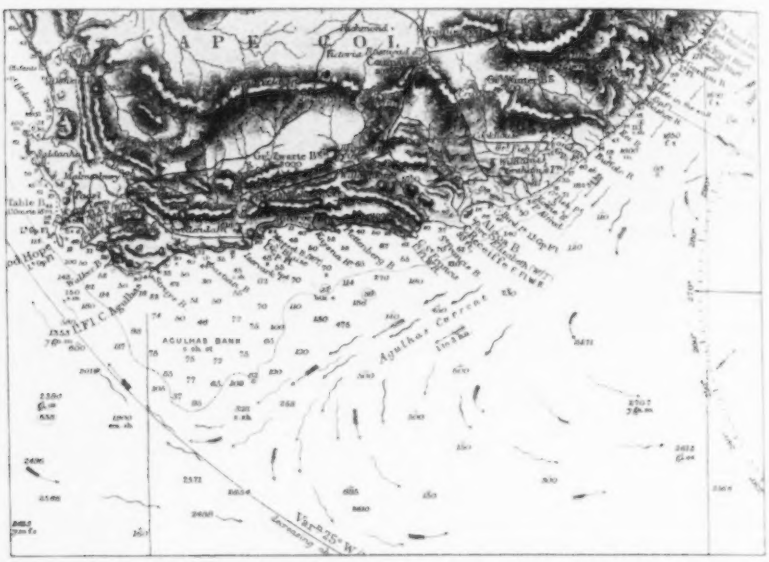


FIG. 1—The Agulhas Bank as depicted on the British Admiralty Chart of the Indian Ocean (1870, with corrections up to 1934).

eastern edge of the bank, and so the greater part of this body of warm water becomes deflected to the southeast.[3] The northeastward drift of sub-Antarctic waters results in a further deflection to the east, the eastward-flowing waters, moving in a higher latitude, being known as the Agulhas return current. Although the main Agulhas stream is deflected, branches flow both over and around the bank to the region between Cape Agulhas and Cape Point. Some of the water of the Agulhas Current also rounds the Cape of Good Hope into the colder seas along the west coast of Africa.[4] It is interesting to note that seeds of *Mucuna gigantea*, a leguminous plant growing in Malaya

[2] L. A. Brooke Smith: A Handbook of Weather, Currents and Ice, for Seamen. *Meteorol. Office Publ. No. 379*, London, 1935.

[3] The main stream, according to Findlay, is actually carried beyond Cape Agulhas, but the checking effect of the bank results in a gradual deflection to the southeast (A. G. Findlay: A Directory for the Navigation of the Indian Ocean, 4th edit., London, [1882]). According to Deacon, however, "the greater part of the sub-tropical water appears to turn back near the edge of the Agulhas bank in about 22° E, but sometimes the current has been found to penetrate westwards of 10° E" (G. E. R. Deacon: The Hydrology of the Southern Ocean, *Discovery Reports*, issued by the Discovery Committee, Colonial Office, London, Vol. 15, pp. 1–124, Cambridge, 1937; reference on p. 75).

[4] The African Pilot, Part 2, 8th edit., London, 1930.

and the East Indies, have been thrown up on the beach at Lamberts Bay, some 130 miles north of Capetown.[5]

It would perhaps seem unnecessary to distinguish between the Mozambique and the Agulhas Currents, for they are essentially one stream of warm water flowing southwards from the tropics; and in many ways it would be more logical to adopt the name "Mozambique Current" for the entire stream.[6] On the other hand, the name "Agulhas Current" is well established, since this was the first of the ocean currents, after the Gulf Stream, to be investigated scientifically.

The main current flows several miles out at sea; but there are countercurrents close inshore that flow in an opposite direction. These are the so-called "occasional currents" of the Admiralty charts. There is not enough evidence to indicate whether they correspond to the compensatory current eddies of the coast of Peru described by Gunther.[7] The existence of these "occasional currents" is suggested by the fact that east of Cape Agulhas the river estuaries and headlands of the south coast of Africa trend eastwards, whereas the Agulhas Current trends southwards and westwards. Evidence is also afforded by the extensive dredging necessary outside the south breakwater of Durban Harbour, from which 1½ to 2 million tons of sand a year is removed.[8] Gilchrist's chart of directions followed by drift bottles along the South African coasts (May, 1899, to May, 1901) may also be taken as evidence of the existence of both the main current and the countercurrents, though Gilchrist did not seem to recognize the distinction between the two.[9]

The effect on sea temperatures of the two sets of currents is that at a given point on the coast line the inshore water will tend to be cooler than the water farther out at sea; hence in considering the records of sea temperature the distinction between coastal stations and island stations some miles from the mainland should be borne in mind. There are, of course, other considerations relating to coastal stations, particularly sea depths and coastal topography. Topography is of especial importance in relation to the southeast winds of summer.

[5] J. Muir: The Beach Drift of South Africa, *Journ. Botan. Soc. of South Africa*, Part 18, 1932, p. 5. In a later contribution Muir refers to his discovery that *Mucuna gigantea* is conspecific with *M. quadrialata*, which grows in tropical East Africa (John Muir: The Correlation of Arrival Sites of Alien Seeds with Ocean Currents, *South African Geogr. Journ.*, Vol. 17, 1934, pp. 13–18; reference on p. 16).

[6] In a previously published note on the ecology and distribution of South African seaweeds this practice was adopted (W. E. Isaac: The Distribution and Zonation of Marine Algæ on the Coasts of South Africa, *British Assn. for the Advancement of Sci., Rept. Ann. Meeting, Norwich, 1935 (105th Year)*, London, 1935, p. 455). Certain other authors (E. S. Barton, George Murray) have also referred to the warm stream as the Mozambique Current.

[7] E. R. Gunther: A Report on Oceanographical Investigations in the Peru Coastal Current, *Discovery Reports*, Vol. 13, pp. 107–276, Cambridge, 1936. See also discussion by R. C. Murphy: Notes on the Findings of the "William Scoresby" in the Peru Coastal Current, *Geogr. Rev.*, Vol. 27, 1937, pp. 295–300.

[8] See the annual *Report of the General Manager, South African Railways and Harbours*.

[9] J. D. F. Gilchrist: Currents on the South African Coast, As Indicated by the Course of Drift Bottles, *Marine Investigations in South Africa*, Cape of Good Hope Dept. of Agriculture, Vol. 2, Cape Town, 1904, pp. 155–165. (For further mention see below.)

As the main current flows some miles out at sea, it may miss certain bays completely.

The available daily records of sea temperature between Durban and Cape Agulhas extending without a break, at least without a serious break, for a number of years are summarized in Table I (p. 656).

The table shows a decreasing gradient of mean annual surface sea temperature from Durban[10] to False Bay, only two stations—Bird Island and Cape Agulhas—falling out of series. In regard to Bird Island it may be recalled that inshore waters are likely to be cooler than the surface waters a few miles out at sea. In addition, it would seem from the Admiralty charts that Bird Island is imprisoned by the main and occasional currents in a body of comparatively still water, and certainly the waters just around the island are very shallow. It is more difficult to account for the high temperature of the sea at Cape Agulhas. The seas around this cape are shallow, and the marked seasonal variation in temperature (Fig. 3) suggests that the southeast winds blow the warmer waters inshore during the summer, with the result that maximum temperatures occur in December, January, and February and a considerable drop in temperature occurs in July and August. This view is also indicated by the temperature data available for Struys Bay, which is shallow and is situated on the east coast of the Agulhas Peninsula, so that the warmer waters are kept in by the summer winds. The average annual temperature of Struys Bay (17.4° C.) is only 0.3° C. lower than that of Cape Agulhas; and, still more significant, the curves of seasonal variation in temperature follow each other closely.

Marchand gives further evidence of the temperature gradients.[11] His figures are based on daily records made at several stations over the seven months June to December, 1930. They are: Durban, 19.7; East London, 16.1; Port Elizabeth, 16.7; Mossel Bay, 16.6; Cape Agulhas, 16.7.

Coastal Waters Influenced by the Benguela Current

The west coast is influenced by the upwelling waters of the cold Benguela Current, which is a current of relatively deep water that gradually comes nearer to the surface. This body of cold water is ultimately derived from the mixing of the cold Antarctic surface waters with warmer waters. These warmer waters are derived from the southward-flowing warm, deep current and the subsurface waters resulting from the mixing of subtropical and sub-Antarctic surface

[10] The sea-temperature data for Durban were kindly placed at the writer's disposal by Mr. W. J. Copenhagen, Department of Agriculture, Capetown.

[11] J. M. Marchand: Hydrographic Investigations during 1930, *Union of South Africa Fisheries and Marine Biological Survey Rept. No. 8.* for 1929–1930, Pretoria, 1932, Special Rept. No. 2. Port St. Johns (16.2° C.) is not included above, since records were made for only three months.

waters at about latitude 40° S. The cold water predominates. The body of mixed water so formed is called by Deacon the "Antarctic intermediate current." It originates 100 to 200 miles north of the Antarctic Convergence, which is situated in about latitude 50° S. and is formed by the abrupt sinking of the Antarctic surface waters to a lower level over the steep slope formed by the ascent toward the

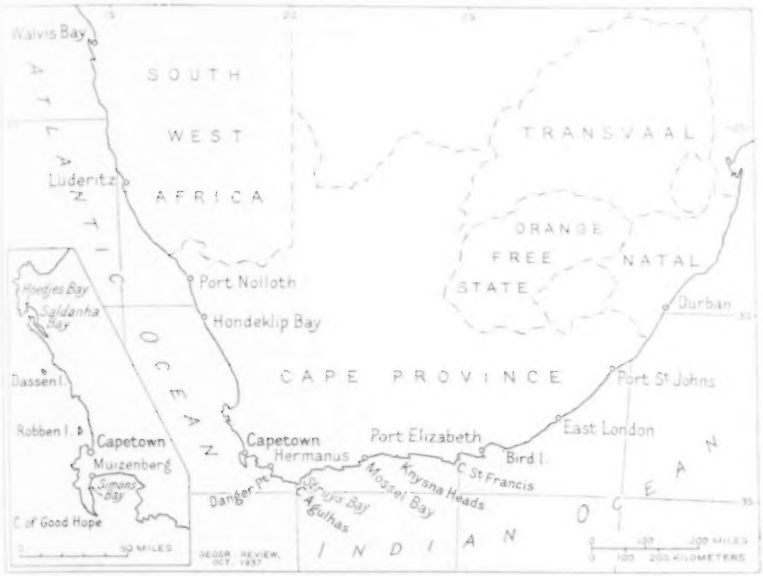


FIG. 2—Map of South Africa showing location of stations discussed in the text. Scale of main map approximately 1 : 20,000,000.

surface of the deep, warm water flowing southwards in each sector of the southern ocean.[12] The Antarctic intermediate water flows northwards and upwells along the west coast of South Africa. Deacon expresses it thus: "The cold water off the south-west coast of Africa is water which has upwelled from the Antarctic intermediate layer into which sub-Antarctic water sinks. The conditions off the south-west coast are therefore partly sub-Antarctic as well as sub-tropical."[13]

Marchand considers that the region of minimum sea temperature lies between Hondeklip Bay and Lüderitz Bay, moving north and south a distance of about 280 miles during the year.[14] The "African Pilot" places the region of minimum temperature farther north: "The temperature of the current remains low as far as latitude 16°S where it begins to rise from 60° [16.6° C.] to about 67° [19.4° C.] in

[12] Deacon, *op. cit.*

[13] G. E. R. Deacon: A General Account of the Hydrology of the South Atlantic Ocean, *Discovery Reports*, Vol. 7, pp. 171–238, Cambridge, 1933; reference on pp. 211–212.

[14] Marchand's conclusions are based on daily observations carried out for periods of four to seven months in 1930 (see *op. cit.*, p. 7).

latitude 15°S, and to 73° [22.8° C.] in about latitude 13°S." At Walvis Bay, just within the tropics, the sea temperature (16.1° C.) is 5.7° C. lower than at Durban (21.8° C.) and 3.2° C. lower than at Port St. Johns (19.3° C.), respectively 7 and about 8.5° of latitude

TABLE I—MEAN SEA TEMPERATURES ALONG THE COASTS OF SOUTH AFRICA

LOCALITY	MEAN ANNUAL TEMPERATURE	MEAN MONTHLY TEMPERATURES	
		MAXIMUM	MINIMUM
Durban	21.8	24.65 (Feb.)	19.25 (Aug.)
Port St. Johns	19.3	21 (Jan.)	16.8 (July)
East London	17.6	19.15 (Jan.)	15.7 (Sept.)
Bird Island	18.2	20.9 (Jan.)	15.9 (Aug.)
Cape St. Francis	17.25	19.7 (Jan.)	14.8 (Sept.)
Knysna Heads	16.8	19.85 (Feb.)	13.5 (Aug.)
Struys Bay	17.4	20.9 (Feb.)	13.8 (July)
Cape Agulhas	17.7	20.9 (Jan.)	13.95 (July)
Danger Point	15.6	17.1 (Jan.)	14.5–14.6 (July, Aug., Sept.)
Hermanus	14.6	17.05 (Jan.)	13.4–13.6 (Mar., July, Sept.)
Simons Bay	15.3	18.4 (Jan.)	13.4 (July)
Muizenberg	16.6	19.6 (Dec.)	13.2 (June)
Capetown Pier	12.8	13.6 (Jan., Apr., Dec.)	12.4 (Sept.)
Robben Island	14.2	15.5 (Dec.)	12.8 (July)
Dassen Island	13.45	14.9 (Dec.)	12.6 (Mar.)
Saldanha Bay	14.8	18.15 (Feb.)	11.8 (July)
Walvis Bay	16.1	18.4 (Jan.)	13.4 (July)

farther south. These conditions make intelligible the discovery by Schinz in 1890 of a species of kelp (*Laminaria Schinzii*) growing at Walvis Bay.[15] This genus of kelp is characteristic of cold and temperate seas, and this is the only record of its existence in the tropics.

Two of the average annual temperature values for the west coast (Table I) are of sea temperatures about islands a few miles out at sea, Robben Island and Dassen Island being respectively about four and nine miles from the mainland. Saldanha Bay is a large lagoon with a narrow extension to the south-southeast for about nine miles and a large protected bay (Hoedjes Bay) to the north. In this the sun-warmed waters tend to be retained and protected from the influence of the open sea. This part of the coast forms an excellent

[15] M. Foslie: Ueber eine neue *Laminaria* (*Laminaria Schinzii*) aus Westafrika, *Bull. de l'Herb Boissier*, Vol. 1, 1893, p. 91.

natural harbor, and but for the absence of an adequate supply of fresh water it might have become the site of a large town. The value for Walvis Bay is based on daily records taken throughout the year in 1932[16] and for ten months in 1902, July and August being without records. In addition, there are a number of monthly averages scattered over several years (January, 1903; February, March, and April,

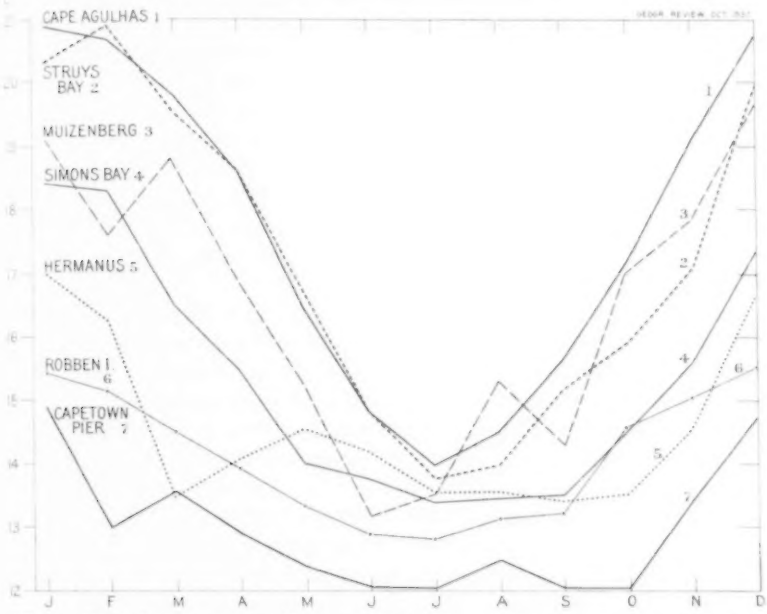


FIG. 3—Graph showing mean monthly sea temperatures at selected stations on the coasts of South Africa. Compare Table I.

1903 and 1904; May and June, 1904; July to December, 1930). The monthly averages of all the records are as follows:

J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	YEAR
18.4	17.4	17.4	15.05	15.4	13.6	13.4	14.2	14.5	14.6	15.8	17.2	15.6

The average for 1932 alone is 15.7° C. Thus it would seem that 16.1° C. is to be regarded as a maximal value.

Along the west coast, as along the east and south coasts, countercurrents flow close inshore in a reverse direction to the main current. Consequently, south of the region of minimum temperature (see above) the inshore water at a given point will tend to be colder than that a few miles out at sea. Confirmation of this statement is found in the seaweed ecology of Dassen Island, which is of a decidedly less cold facies than that of the opposite mainland at Yzerfontein Point.

[16] Data supplied by Mr. W. J. Copenhagen.

Comparison of sea temperatures at Capetown and Robben Island is also suggestive.

Annual temperatures at Robben Island for the six years 1898 to 1903 average 14.2°; the lowest temperature was 13.4°, the highest 15.3°. At the end of the Adderley Street Pier, Capetown, average annual temperatures for 1934 and 1935 were 13.0° and 12.7° respectively. Thus the lowest temperature at Robben Island was 0.6° C. above the Capetown average annual temperature and 0.4° C. above the higher of the two averages for Capetown Pier.[17] Both sets of data show the same degree of seasonal variation (Fig. 3).

Marchand's temperature values averaged from daily records made over a period of four to seven months during the latter half of 1930 are as follows: Hondeklip Bay, 12.04° C.; Port Nolloth, 12.3° C.; Lüderitz Bay, 13.1° C.; Walvis Bay, 14.6° C.[18]

Between Cape Agulhas and the Cape Peninsula

This region between Cape Agulhas and the south end of the Cape Peninsula is not directly within the sphere of influence of either the Agulhas or the Benguela Current, but, as was pointed out above, branches of the Agulhas Current escape into it. Also, from time to time, as a result of wind action, colder or warmer water masses invade the region. Furthermore, there is a seasonal effect, since the Agulhas Current flows more strongly and extends farther west in the summer and the Benguela Current extends farther east in the winter. This is confirmed by Marchand from a consideration of the salinity values of Table Bay, St. James, and Cape Agulhas. The sea temperatures of this region are higher than those of the west coast of the Cape Peninsula. The indirect influence of the Agulhas Current is greater; furthermore, in the summer the frequent and characteristic southeast winds tend to keep in the warmer waters, whereas the same winds on the west coast tend to blow away the warmer surface waters, and upwelling of the deeper colder water results.

The average annual temperatures of Danger Point, Hermanus, and Simons Bay are decidedly lower than that of Cape Agulhas, but that of Muizenberg is of the same order. The temperature of Hermanus (14.6° C.) is lowest. The relatively high temperature of the sea around Danger Point (15.6° C.) is probably due to the closer proximity of the warmer waters off Cape Agulhas. Topographical features in conjunction with the seasonal distribution of the southeast winds account for the differences in the temperatures of Hermanus and False Bay.

[17] The writer is indebted to the Manager of the Bathing and Seaside Attractions, Capetown, for the sea temperatures off Adderley Street Pier.

[18] Marchand, *op. cit.* The value for Saldanha Bay (18.2° C.) is based on the records of only two months and so is not included above. For abnormally high temperatures at Saldanha see p. 8.

The influence of local features, especially winds, is seen in the temperatures of stations on the Cape Peninsula (Fig. 3). The average annual temperature of Simons Bay (Roman Rock) is 1.1° C. higher than that of Table Bay (Robben Island). In late winter and early spring the temperatures are almost the same, but the range is much greater for False Bay, because of the banking up of sun-warmed waters by the southeast winds of summer. Muizenberg,[19] at the north end of the east coast of the Cape Peninsula, presents an extreme case of this phenomenon. The average annual temperature of Muizenberg is 1.3° C. higher than that of Simons Bay, 2.4° C. higher than that of Robben Island, and 3.8° C. higher than that of Capetown Pier; in fact, it is of the same order as that of Knysna Heads (16.8° C.), about 270 miles farther east and directly subject to the Agulhas Current. Furthermore, the sea at Muizenberg shows a marked seasonal variation in temperature—a range exceeding that of Simons Bay.

The high temperatures in False Bay are due not only to the influence of southeast winds and the absence of a cold current but also to its large expanse of shallow waters sheltered by extensive headlands from the more open sea. This explains the fact that the average annual sea temperature of Simons Bay is 0.8° higher than that of Hermanus. A comparison of the seasonal temperature curves shows the difference to be more marked than average annual temperatures indicate, since the sea temperatures of Hermanus are more uniform throughout the year than those of Simons Bay (Fig. 3).

Marchand has presented evidence indicating that the eastern part of False Bay has lower sea temperatures than the western part—a further indication of the important effect of southeast winds on summer sea temperatures.

Earlier Views

The explanations of the temperatures around the Cape Peninsula advanced above have not been held by most previous writers. The most detailed work done heretofore is that carried out by Gilchrist in 1902. He contended that "a considerable body of the warm Agulhas current flow[s] into False Bay" and that some of the warm water passes round Cape Point moving northwards at an increasing distance from land. He found that sea temperatures on the west coast rise toward the open sea and that the depth of greatest change increases with increasing distance from the land. Between the warm water from False Bay and the land there is "a body of water of lower temperature and specific gravity, being doubtless the welling up of the Antarctic current passing under the warm current and impinging on the west side of the Peninsula. From the sudden and marked

[19] Data for sea temperatures at Muizenberg were obtained from the Manager of the Bathing and Seaside Attractions, Capetown.

changes in temperature in this region it is evident that there is considerable commingling of the currents."[20] Gilchrist was, of course, well aware of the slenderness of his evidence, though he does not seem to have had any doubts of the essential correctness of his views.

A second contribution to the oceanography of South African seas was published by Gilchrist in 1903, in which he deals with the trend of the currents as indicated by the course of drift bottles. The bottles of one series were dropped from mail steamers at fairly regular intervals at fourteen definite points along the coast between Capetown and Natal. The bottles of a second series were set adrift from a government vessel at various places at which it happened to be engaged in marine investigations.

A chart of the directions taken by the drift bottles indicates a movement southward along the east coast, westward along the south coast, and northward along the west coast; but along each of these three coasts bottles also drifted in opposite directions. This becomes intelligible when the existence of both the main current and countercurrents is recognized—which distinction, however, Gilchrist did not recognize. A detailed analysis of the results obtained is not warranted, since not only is the investigation subject to the limitation indicated above but also the entire method is open to question, for slight wind effects would have too much influence on the movements of the small (2-ounce) bottles used.[21]

Other Oceanographical Data Relating to South African Seas

Less is known of the chemical properties of the South African seas, but the chemical contents of the waters are, of course, broadly related to temperature.

Along the east and south coasts a slightly and irregularly decreasing salinity gradient accompanies the decrease in temperature. Irregularities are brought about by local conditions, such as the inflow of river water into the sea. The waters influenced by the Benguela Current, however, show a decidedly lower salinity than that of the warmer waters.[22] "Normally it seems that Durban[23] has the highest

[20] J. D. F. Gilchrist: Observations on the Temperature and Salinity of the Sea around the Cape Peninsula, *Marine Investigations in South Africa*, Vol. 1, Cape Town, 1902, pp. 181–217; references on p. 216.

[21] In an investigation of the water circulation of Hudson Bay a metal drag was suspended from each drift bottle by about three feet of galvanized wire. This was done in order to keep the bottle upright and almost wholly submerged and also to cause the bottle to follow the movement of the upper three feet of water rather than the movement of the surface water. The results obtained were considered to be satisfactory. (See H. B. Hachey: The Circulation of Hudson Bay Water as Indicated by Drift Bottles, *Science*, Vol. 82 (N.S.), 1935, pp. 275–276.)

[22] J. M. Marchand's salinity determinations published in the *Union of South Africa Fisheries and Marine Biological Survey Reports*, Nos. 8 to 11 inclusive (for 1929–1930 to 1933 inclusive), and especially Special Report No. 2 for 1929–1930 (see footnote 11); C. F. Juritz: Physical and Chemical Observations in Marine Survey of S. S. "Pickle," *ibid.*, Special Rept. No. 2, for 1921–1922.

[23] The northernmost point on the east coast in Marchand's investigation.

salinity at all times of the year for the whole coast. From this point there is a gradual decrease in salinity as we proceed southerly and westerly. After passing Cape Agulhas the salinity still decreases gradually until a minimum is reached at Lüderitz. At all times, therefore, Lüderitz seems to be the location of minimum salinity on the South African coast. Further north from here there is a fairly rapid rise in salinity."[24]

The salinity of both colder and warmer waters also shows a seasonal variation, mostly with maximum values in December and January and minimum values in June and July, in accord with the seasonal variation of temperature. The salinity of the warmer waters ranges from 36.5 per mille to 36.9 per mille; the salinity of the waters of the west coast ranges from 36.36 per mille to 36.0 per mille.[25] Individual values range above and below these orders of salinity.

An investigation carried out under the direction of Juritz indicates a close correlation between total inorganic nitrogen (mostly nitrate) and sea temperature, the amount of inorganic nitrogen varying inversely with temperature. This is the only investigation of its kind known to the present writer. It may be added, however, that Antarctic surface water contains large amounts of nitrate.[26]

Deacon has shown that the phosphate content of Antarctic surface water is much higher than that of the surface waters of more temperate seas.[27] Consequently, as water from the Antarctic is carried northwards along the west coast of South Africa, it is reasonable to conclude that the phosphate content of these colder waters is much higher than that of the warmer waters along the south and east coasts of South Africa. There are very few published values for the phosphate content of South African coastal waters. The following data (for surface waters) are taken from the report of the *Discovery II*.[28]

Station Number	Locality	Phosphate Content (P_2O_5) (*mg. per cu. m.*)
436	Off Durban	21
424	Off Port Elizabeth	49
421	Off Danger Point	51

Except for a few isolated observations, precise data on oxygen content are lacking, but the colder waters must naturally be richer

[24] Marchand, Hydrographic Investigations during 1930, p. 13.

[25] These values are based on salinity determinations published by Marchand in the *Union of South Africa Fisheries and Marine Biological Survey Reports*, Nos. 8 to 11 inclusive (for 1929–1930 to 1933 inclusive).

[26] Deacon, A General Account of the Hydrology of the South Atlantic Ocean.

[27] *Ibid.*

[28] "R.R.S. 'Discovery II.' Stations 300–700." pp. 6–165 in *Discovery Reports*, Vol. 4, pp. 1–232 Cambridge, 1932.

in dissolved oxygen than the warmer waters. From a biological point of view this is the most important consequence of marked differences in sea temperature. A more abundant supply of oxygen will make possible a denser growth of seaweed, which in turn will further increase the oxygen content of the water, owing to the evolution of oxygen by the plants in the daytime photosynthesis. It has been shown that the water over coral reefs is relatively richer in oxygen, because it is evolved by small green algae growing in association with the corals. It has also been shown that a rich growth of seaweeds increases the oxygen content of rock pools during the day.[29] It is to be expected, therefore, that the oxygen content of the waters around the beds of kelp will be higher than in the sea farther out; consequently the large beds of kelp are an additional source of oxygen that is absent in the warmer seas, since coral reefs are not found along the east coast much farther south than latitude 15° S.

Data on hydrogen-ion concentration are very scant. Hogben and Zoond carried out an investigation in 1928 and came to the conclusion that there is no significant difference in this respect in the waters along the east and west coasts of the Cape Peninsula. The values obtained ranged from 8.02 to 8.33, but values throughout this range were recorded in both warmer and colder waters.[30] The meager data on hydrogen-ion concentration in South African coastal waters contained in the report of the *Discovery II* confirm this conclusion for South African seas. The recorded values, however, show a somewhat higher order of hydrogen-ion concentration (pH 8.2 to pH 8.3).

Marchand demonstrated a decided seasonal variation in hydrogen-ion concentration at St. James in 1930. Maximum values were recorded in February and December and minimum values in July, the curve of seasonal variation being of the same character as those of temperature and salinity.

Effects of Differences in Coastal-Water Temperatures

Reference was made above to contrasts in the seaweed growth of the colder and warmer seas. Attention is first attracted by the greater size, density, and luxuriance of seaweeds in the colder waters. This is true both of those weeds growing between tidemarks and of those growing beyond low-water mark, of which only the tips are exposed. The growth of kelps beyond low-water mark, in many places in extensive formation, is characteristic of the colder waters. The sea bamboo (*Ecklonia buccinalis*) is a common species of kelp in the cold waters and often reaches a height of more than 20 feet. In the warmer waters

[29] T. A. Stephenson, A. Zoond, and J. Eyre: The Liberation and Utilization of Oxygen by the Population of Rock Pools, *Journ. of Experimental Biology*, Vol. 11, 1934, p. 162.

[30] Lancelot Hogben and Alexander Zoond: A Note on the Hydrogen Ion Concentration of Surface Waters around the Cape Peninsula, *South African Journ. of Sci.*, Vol. 25, 1928, pp. 325–328.

the seaweeds are small and the large kelps are absent. However, species of *Sargassum*, absent in the colder waters, are present in many places. The Cape laver (*Porphyra capensis*) is widely distributed in both warm and cold waters. In the warmer waters it becomes rare and of small size, but in the colder waters it forms extensive and dense masses of large-sized individuals. In the warmer seas the lime-incrusted seaweeds (corallines), which play an important part in the building of coral reefs in the tropics, are much more abundant and luxuriant and show a greater variety of forms.

In the colder seas the larger piscivorous birds are more numerous, such as the trek duiker, or cormorant (*Phalacrocorax capensis*), Malagash, or Cape gannet (*Sula capensis*), and jackass penguin (*Spheniscus demersus*). The duiker extends as far north as the Congo on the west coast but only as far as Durban on the east coast and is commonest in the region between Table Bay and Walvis Bay. The Malagash extends from the French Congo to Zanzibar but is most numerous along the coasts of the Cape, particularly the west coast. The jackass penguin is commonest in the colder seas and does not extend beyond Algoa Bay in the warmer seas.[31]

The elasmobranchs, or cartilaginous fishes, which include the sharks, dogfishes, and skates, are characteristic of the warmer seas, and several species are confined to the warm waters of the east coast. In a recent *Fishery Bulletin* by Marchand[32] not a single species is listed that is confined to the west coast, and only five of the 35 listed elasmobranchs are found on the east, south, and west coasts. The opening of a shark fishing factory on Durban Bluff in 1930 and of a second one the following year indicates the abundance of these fish in warmer waters, though the venture has not been so successful as anticipated.[33]. The teleosts, or bony fishes, are not so purely warm water. Marchand lists two species that are confined to the west coast, 19 to the south and east coasts, and 17 to the east coast; only 16 species are listed that are found on all these coasts. Some of these species may, of course, be rare outside their more usual range of distribution.

The Cape crawfish (*Jasus lalandii*)—a relative of the lobster and the fresh-water crayfish of Europe—has been studied in fair detail.[34] It is almost entirely confined to the west coast, being found in abundance as far north as Mercury Island, in about 26° S. The northernmost record is about sixty miles north of Walvis Bay. Its abundance in

[31] F. W. Fitzsimons: The Natural History of South Africa: Birds, 2 vols., London, 1923, Vol. 2.

[32] J. M. Marchand: The South African Marine Fishes of Commercial and Angling Importance, *Fishery Bull. No. 2*, Pretoria, 1935. A total of 108 species is listed, the fish dealt with being primarily those of commercial and sporting interest and importance.

[33] The South and East African Year Book & Guide, 43rd annual edit., London, 1937.

[34] *Marine Biological Report No. 1*, Province of the Cape of Good Hope, Union of South Africa, Cape Town, 1913; C. von Bonde and J. M. Marchand: The Natural History and Utilization of the Cape Crawfish, *Fishery Bull. No. 1*, Pretoria, 1935.

colder waters is indicated by the number of crawfish canning factories along the west coast. It is only occasionally found in False Bay, and a few individuals have been found as far east as Bird Island. These, however, were small. Along the coast of Natal the Cape crawfish is replaced by quite different species. Some time ago a number of enterprising East London citizens attempted to remedy the absence of this species from the coasts of the Eastern Province by importing a shipload of Cape crawfish from Capetown. "The consignment arrived safely, and was placed in a suitable locality, but apparently the fish did not thrive, as they were never again seen."[35] The matter was not investigated in detail, but the obvious conclusion would seem to be that the temperature was unsuitable. In regard to South African crawfish in general Von Bonde and Marchand remark that "the crawfishes of South Africa seem to conform to the general rule as to distribution of fishes, and probably other South African marine fauna, namely, on the West coast the species are few in number, but the individuals are numerous, while on the East coast the number of species is large but the individuals are few."[36]

[35] *Marine Biological Report No. 1*, 1913, p. 26.
[36] Von Bonde and Marchand, *op. cit.*

ANNUAL-VARIABILITY RAINFALL MAPS OF THE GREAT PLAINS

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THE present study is undertaken in the belief that the theory of probabilities applied in a new way to weather data may offer an approach to more rational agricultural operations. The region selected is the Great Plains, an area admirably adaptable to a demonstration of the principle involved and, correlatively, an area where the need of applied climatological studies is acute.

When a worker borrows a tool specially designed for use in some field of activity other than his own, he cannot hope for satisfactory results if the tool is not adaptable to his particular needs. The geographer who uses tools from the climatological field—means, departures from normal, percentages of variability, maxima, minima, and the like—must see that he applies them correctly, or misconceptions will arise. He must fit the results of abstract mathematical analysis to the actualities of human activities. We have heard a good deal lately of the inadequacy of means as used in geographical study. Here is an example.

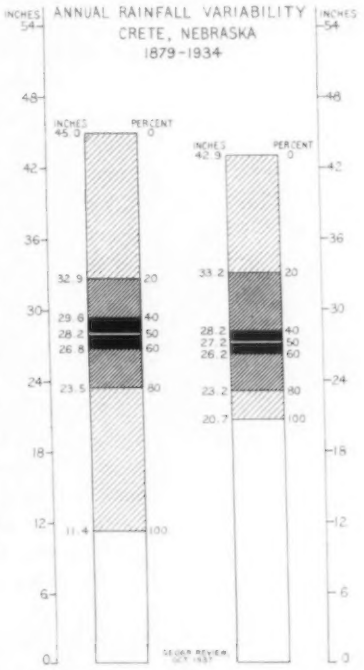

FIG. 1—Two methods of computing annual rainfall variability.

AN EXAMPLE FROM NEBRASKA

A specific illustration of the factors involved in two methods of finding central tendencies and related values is well shown in the 54-year record of rainfall at Crete, Nebr. When percentile departures are calculated by use of the *mean annual* and the *standard deviation*, the results appear as shown in Figure 1. The left part of the graph shows that Crete received 11.4 inches or more (minimum) of rainfall 100 per cent of the time, 28.2 inches or more (mean) 50 per cent of the time, and more than 45.0 inches (maximum) 0 per cent of the time. Intermediate percentile values are shown also.

When the annual amounts of rainfall are arranged in a volume sequence and corresponding percentile points are found by counting, the results appear as shown also in Figure 1. The right part of this graph shows that Crete received 20.7 inches or more (minimum) of rainfall 100 per cent of the time, 27.2 inches or more (median) 50 per cent of the time, and more than 42.9 inches (maximum) 0 per cent of the time. Intermediate percentile values are shown also.

All the values in the left part of Figure 1 are calculated to fit a normal curve of distribution and thus account for the symmetrical arrangement of the percentile points in relation to the mean. The percentile values in the right part of Figure 1, although not symmetrical, do represent conditions over the 54 years as they actually were.

A further examination of the graph reveals some interesting contrasts. If the mean is taken as the measure of central tendency, then Crete received 28.2 inches or more of rainfall 50 per cent of the time; whereas, according to the right part of the figure, 28.2 inches or more of rain actually fell only 40 per cent of the time. If departures are calculated from the mean and the standard deviation, Crete's minimum rainfall was 11.4 inches, whereas the minimum actually was 20.7 inches.

In "The Analysis of Rainfall Probability" Mr. P. R. Crowe[1] stresses the dangers that beset the geographer in his use of the climatologist's tools. Mr. H. A. Matthews, in a study of rainfall in India, calls attention to the same possibilities of error of interpretation.[2] In a recent article Mr. Crowe applies his methods and techniques in a study of rainfall variability of the Great Plains.[3]

The procedure followed in constructing the annual-variability rainfall maps of the Great Plains presented herewith is similar to that followed by the author in his earlier study of Nebraska.[4]

The records of about 500 stations in ten Great Plains states were used in constructing the five maps described in this paper. The annual amounts of rainfall at each station for the recorded series of years were arranged in a volume sequence, ranging from the highest to the lowest. From this sequence the maximum, minimum, and 20, 40, 50, 60, and 80-percentile values were obtained. For example, Manhattan, Kan., according to a 76-year record, received 36.7 inches or more of rainfall 20 per cent of the time, 32.9 inches or more 40 per cent of the time, 30.3 inches or more 50 per cent of the time, 29.2 inches or more 60 per cent of the time, and 26.1 inches or more 80 per cent of the time. Moreover, Manhattan never in the 76-year period received more than

[1] *Scottish Geogr. Mag.*, Vol. 49, 1933, pp. 73–91.

[2] H. A. Matthews: A New View of Some Familiar Indian Rainfalls, *Scottish Geogr. Mag.*, Vol. 52, 1936, pp. 84–97.

[3] P. R. Crowe: The Rainfall Regime of the Western Plains, *Geogr. Rev.*, Vol. 26, 1936, pp. 463–484.

[4] E. E. Lackey: Annual Variability Rainfall Maps for Nebraska, *Monthly Weather Rev.*, Vol. 63, 1935, pp. 79–85. Compare also his article "A Variability Series of Isocrymal Maps of Nebraska," *Geogr. Rev.*, Vol. 26, 1936, pp. 135–138.

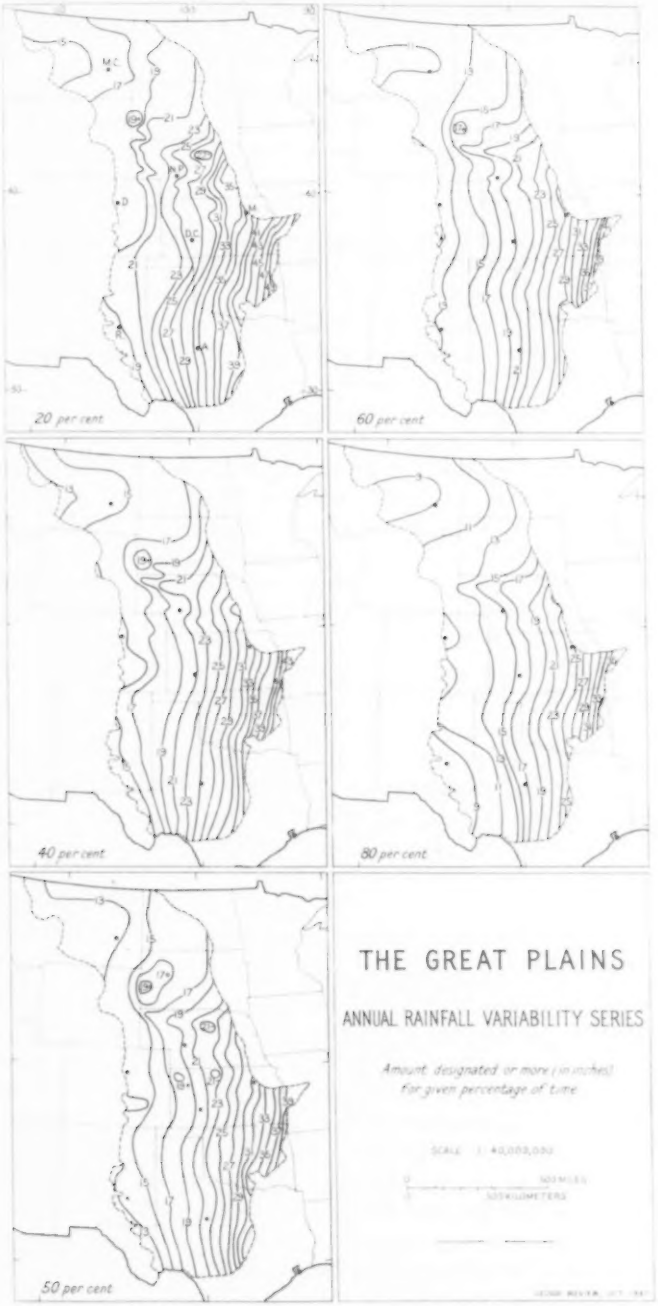

FIG. 2—A series of annual rainfall variability maps for the Great Plains. Key to stations appearing in Figures 3 and 4: M, Manhattan, Kan.; A, Abilene, Tex.; DC, Dodge City, Kan.; R, Roswell, N. Mex.; D, Denver, Colo.; MC, Miles City, Mont.

50.8 inches (maximum) and never less than 15.1 inches (minimum), or, to put it in percentile form, Manhattan received more than 50.8 inches 0 per cent of the time and 15.1 inches or more 100 per cent of the time.

How Much Rainfall May Be Expected

Usually the question concerning the amount of rainfall any place receives is answered by stating the mean annual. This is obtained by dividing the total number of inches of rainfall for the given consecutive years by the number of years in the record. For example, the total rainfall at Manhattan, Kan., during a period of 76 years was 2370.9 inches. The mean, therefore, is 31.2 inches. For two reasons at least, the mean is not a satisfactory measure. First, there is nothing to indicate the relative number of times the amount was above or below the computed mean of 31.2 inches. At Manhattan the precipitation was above the mean 34 times and below the mean 42 times. It is ordinarily assumed that the distribution is normal. This is seldom the case; but when it is, the mean and median have identical values. At Manhattan the mean is 0.7 inch above the median. This signifies that the average departure above the mean is greater than the average departure below it. Moreover, rainfall below the mean shows less variability than that above. Even so, departures below the mean usually involve greater hazards in crop production. Secondly, both the mean and the median have their limitations in that they are measures of central tendency only. Anyone who relies on these two measures is thinking approximately in terms of even chances. What are other chances? The annual-variability rainfall maps in this series answer the question concerning the chances for 20, 40, 50, 60, and 80 per cent of the time.

Annual Rainfall Variability at Selected Stations

The rainfall is considerably higher on the eastern margin of the Great Plains than it is on the western margin. This is well shown on the vertical 50 per cent line in Figure 3. The medians for Manhattan and Abilene, on the eastern margin of the Great Plains, are 30.3 inches and 24.5 inches respectively. Denver, Dodge City, and Miles City, near the western margin, receive 13.9 inches, 19.6 inches, and 12.9 inches respectively. The 20 per cent line indicates the amount or more of rainfall[5] the six stations received 20 per cent of the time, and the 80 per cent line the amount or more received 80 per cent of the time. At Manhattan the range between the amount received 20 per cent of the time and that received 80 per cent of the time is 10.6 inches, which is one-third of the median.

[5] It must be emphasized that here and in the accompanying maps the amount of rainfall given is the *minimum*, and how often and by how much the given amount was exceeded are not indicated.

At Roswell, N. Mex., the range between the 20 per cent and 80 per cent amounts is about two-thirds of the median; at Manhattan the range is just a little more than one-third of the median. It is evident from the record that rainfall is more reliable at Manhattan than at Roswell.

Of course, the range in inches between the 20 per cent and 80 per cent amounts is not the measure of the hazards involved when different

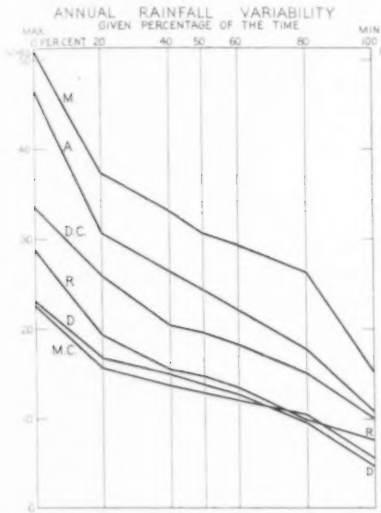

FIG. 3

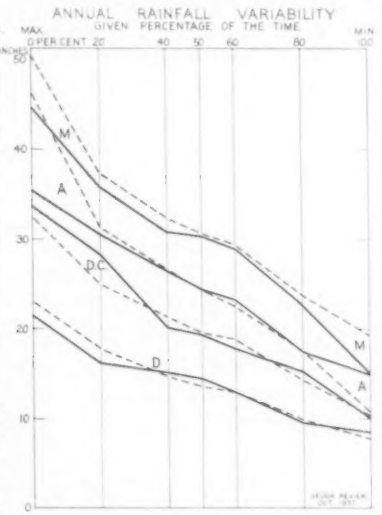

FIG. 4

FIG. 3—Annual rainfall variability of selected stations in the Great Plains. The stations (with years of record) are: M, Manhattan, Kan. (76); A, Abilene, Tex. (48); DC, Dodge City, Kan. (60); R, Roswell, N. Mex. (56); D, Denver, Colo. (62); MC, Miles City, Mont. (56).

FIG. 4—A comparison of annual rainfall variability during the two halves of the period of record at selected stations of the Great Plains. The first half of the record is shown by a solid line, the second half by a dashed line. The stations (with years of record) are: M, Manhattan, Kan. (76); A, Abilene, Tex. (48); DC, Dodge City, Kan. (60); D, Denver, Colo. (62).

stations are being compared. This would be the case, however, if the medians were about equal and the other factors were comparable. The hazards at Abilene are probably greater than at Manhattan because the median is lower and the range between the 20 per cent and 80 per cent amounts is greater.[6] The corresponding range at Dodge City is 54 per cent of the median, and at Miles City it is only 43 per cent.

These illustrative explanations concerning Figure 3 should serve to show some of the advantages in knowing the annual rainfall variability at any given place. Although Figure 3 shows what has actually happened at six stations in the Great Plains, the work sheets associated

[6] Factors other than precipitation, such as evaporation, wind, and soils, are not here taken into account.

with this study indicate corresponding facts for 500 stations. Graphs similar to Figure 3 could be made for each station. The five maps constructed from these data generalize conditions for the Great Plains, and they present a fair picture of annual rainfall variability for any place in the region. The 20, 40, 50, 60, and 80-percentile maps yield about the same information for all parts of the region that Figure 3 shows for the six selected stations. For example, Figure 2 shows that North Platte, Nebr., receives about 23 inches or more of rainfall 20 per cent of the time, 18 inches or more 50 per cent of the time, and 14 inches or more 80 per cent of the time. The range between the 20 per cent and 80 per cent amounts is 9 inches, which is just one-half of the median. Thus annual-variability values may be obtained from the maps for any place in the Great Plains.

Reliability of the Record

To determine the reliability of the rainfall in the Great Plains for the study of variability, several stations with long-time records were given special attention. The data given in Figure 4 show the results for four of these stations. For each station the annual rainfall variability during the first half of the period of record was compared with the variability during the second half of the period. For Manhattan, with a 76-year record, the medians for the two halves were almost identical (30.3 inches and 30.4 inches respectively); but for each of the stated periods of variability the record runs higher for the second half than for the first. It may be noted that for each of these four stations the rainfall is quite consistent throughout the period of record and that variabilities during the first half do not depart widely from those of the second half except occasionally in case of the maxima and the minima.

GEOGRAPHICAL RECORD

NORTH AMERICA

An Evaporation Survey of Ohio. The rainfall record is an inadequate index of the availability of moisture for biological and other purposes. The losses by runoff, subsurface drainage, and evaporation leave a residuum that is available for plant use. The development of plant life is dependent not only on the moisture available in the soil but on the moisture content of the atmosphere and the corollary phenomena, the rate of evaporation and transpiration. The moisture content of the atmosphere can be determined directly and expressed as the vapor pressure or the relative humidity. The significance of the moisture in the soil and in the atmosphere may be approached indirectly by a consideration of the rate of loss of moisture from the soil to the atmosphere. Ecologists have long recognized the habitat significance of evaporation; but compared with the relatively numerous rainfall records, evaporation data are neither so abundant nor so reliable.

One of the first investigations of the relation of evaporation and the geographical distribution of the natural vegetation was published by Transeau in 1905 (Forest Centers of Eastern America, *Amer. Naturalist*, Vol. 39, 1905, pp. 875–889). Since the publication of this pioneer study a succession of papers on this same subject have accumulated into a voluminous literature. Some of these studies have been essentially observational; others lie definitely in the field of ecology and represent an attempt to discover relationships between evaporation and vegetation.

The ecological significance of the moisture content of the atmosphere can be determined only approximately. By an analysis of the rate of evaporation in its relation to precipitation an index may be derived that may be of value in the study of the distribution not only of the natural vegetation but of economic plants and of animals, particularly insects.

Partly because of the inadequacy of evaporation data and also because of an evident relation between the habitat and the distribution of the corn borer and the Mexican bean beetle, the U. S. Bureau of Entomology, the Botany Department of the Ohio State University, and the Department of Entomology of the Ohio Agricultural Experiment Station coöperated in an evaporation survey of Ohio (J. D. Wilson and J. R. Savage: An Evaporation Survey of Ohio, *Ohio Agric. Exper. Sta. Bull. 564*, 1936). Weekly observations were made at a number of stations during the frost-free periods of the years 1926 to 1931, using the Livingston type of standardized, spherical, white atmometer. The data obtained from the Livingston-type evaporimeter are expressed in cubic centimeters. The results were used with the precipitation to represent the rainfall-evaporation ratio or, inverted, the evaporation-rainfall ratio. This latter ratio expresses directly the number of cubic centimeters lost by evaporation for each inch of precipitation. This quantity can be converted into inches by dividing the number by 190.

The average rates of evaporation over the four-year period 1928 through 1931 were respectively 2500, 3000, 4800, and 3300 cubic centimeters. The extremely high evaporation of 1930 was due to the low rainfall and high temperatures of the summer season. The evaporation in 1930 was about 65 per cent greater than the average for the years 1928, 1929, and 1931, though the precipitation was only 46 per cent as great as the average for the three years. These and other data permit the authors to observe that "evaporation increases with a decrease in rainfall in such a manner that halving the rainfall may be expected nearly to treble the value of the evaporation-rainfall ratio."

Stations along Lake Erie have a greater rate of evaporation than those in central Ohio or along the Ohio River. Less rainfall along the lake shore favors the greater evaporation, but the slightly higher temperatures in the southern part of the state

should favor the river-valley stations. Another factor, namely wind velocity, seems to be important in explaining the greater evaporation along the lake shore. Wind velocities at Cleveland and Toledo averaged 10.3 miles an hour; whereas at Cincinnati and at Parkersburg, West Virginia, the velocity was only 4.6 miles an hour.

The rainfall and evaporation data combined into a rainfall-evaporation ratio yield a better criterion or index of the effectiveness of moisture in plant growth than either factor alone. The inversion of the R/E ratio into an E/R ratio does not alter its value as an index. A study of crop yields and evaporation indicates that yields could be predicted with but little more accuracy than could be obtained by the use of rainfall data alone. Although this investigation did not in itself prove conclusively a significant correlation between the E/R ratio and crop yields, supplementary studies of limited areas demonstrate that evaporation data have important prognostic value in crop production.

GUY-HAROLD SMITH

The Eastern Boundary of Rhode Island. That our state boundaries, although inconspicuous, possess some of the attributes of international frontiers is seldom brought to mind. Yet a good deal of friction has been created in the adjustments that have necessarily been made in the lines laid down in advance of close settlement. Edward L. Ullman surveys three centuries of controversy over one interstate frontier in "The Historical Geography of the Eastern Boundary of Rhode Island" (*Research Studies of the State College of Washington*, Vol. 4, 1936, pp. 67–87). As has been true of many boundaries, trouble arose from conflicting charters drawn without accurate information and from the choice of bays and rivers, conspicuous on early maps and supposedly easy to find in the field, instead of more harmonious lines along divides or through permanent barrens.

Narragansett Bay was an original boundary of Plymouth Colony, which was absorbed, in 1691, into Massachusetts. But for the religious conflict attending its founding, Rhode Island might have been swept into this union. So obviously was Narragansett Bay the focus of Rhode Island that Roger Williams had obtained, in 1663, a charter removing the boundary of Plymouth three miles east of the eastern shore. This charter was revoked, but, in 1746, Rhode Island, capitalizing the quarrel between Massachusetts and the crown, secured most of its provisions. Although poorly and dishonestly surveyed and provoking many minor disputes, the line then marked served for more than a hundred years. In the nineteenth century the cities of Providence and Pawtucket, Rhode Island, and Fall River, Massachusetts, spread their suburbs across the state line. An exchange of lands in 1861 ended this awkward situation. Finally, certain "natural" parts of the boundary (high-water marks along streams and ponds), proving difficult to mark, were replaced in 1898 by straight lines.

Ullman applies to this boundary the nomenclature developed by Hartshorne. "Antecedent" describes portions older than stated phases of settlement. "Superimposed" describes portions shifted into disconformity with landscape features. The significance of "subsequent" seems less clear. Hartshorne applied this term to any boundary drawn later than some major stage of occupance; i.e., it is the opposite of "antecedent" (Suggestions on the Terminology of Political Boundaries, *Mitt. Vereins der Geographen an der Univ. Leipzig*, No. 14–15, 1936, pp. 180–192). He had earlier called the present Upper Silesian boundary "subsequent or superimposed," suggesting synonymy (The Upper Silesian Industrial District, *Geogr. Rev.*, Vol. 24, 1934, pp. 423–438; reference on p. 438). Ullman states that the eastern boundary of Rhode Island "is subsequent in some respects, superimposed in others," suggesting antonymy. The reviewer proposes the following codification: (1) "Antecedent" and "subsequent" express only the time relationship of the boundary to stated phases of occupance. (2) "Conformable" and "disconformable" express the adjustment of the boundary to the present or stated landscapes. (3) A boundary

that has been moved may be called "transposed." A disconformable transposed boundary is "superimposed." (4) To distinguish between minor and major relationships, one may speak of the "site" and "general situation" of a boundary, borrowing terms long used by Raoul Blanchard in urban geography.

Almost simultaneously with Ullman's paper appeared a set of six maps, with explanatory text, by J. H. Cady (Rhode Island Boundaries 1636–1936, *Rhode Island State Planning Board Special Rept. No. 7*, 1936). Cady's handsome maps invite a study of Rhode Island internal boundaries. Early divisions (map of 1659–1703) suggest the "long lot" development of French Canada, but land transport and interior settlement give the 1874–1936 map a patchwork pattern. In depicting the eastern state line, Cady shows the gore between Blackstone River and the Pawtucket meridian to have been claimed by Massachusetts until 1746, in which he is supported by the Paullin "Atlas of the Historical Geography of the United States" (Pl. 97C). On the other hand, E. M. Douglas (Boundaries, Areas, Geographic Centers and Altitudes of the United States and the Several States, *U. S. Geol. Survey Bull. 817*, 2nd edit., 1930, p. 91) substantiates Ullman's view that the Pawtucket meridian was agreed on early in the eighteenth century. Less important differences are a slight misdrawing of the 1746 boundary at Mt. Hope Bay on Ullman's map and Cady's omission of the high-water boundary superseded by straight lines in 1898.

These two publications illustrate the superiority of detailed studies over speculations not based on field work. This short boundary falls into several segments, differing in history and in conformity with past and present needs. All parts of the line (with the possible exception of the Pawtucket meridian) have been transposed once or more. Near cities, transposition has increased conformity with the cultural landscape. Elsewhere, minor shifts of site have led to boundaries superimposed against the wishes of landowners. The line as a whole represents a compromise between the naturally marked "Naragansetts river" and the more harmonious drainage divide between that and Cape Cod and Massachusetts Bays. The low degree of hindrance of the height of land has made possible the continuous attachment, geographical and emotional, of Fall River to Massachusetts.

STEPHEN B. JONES

An Active Volcano in Chiapas. In an article entitled " 'El Chichón,' volcán en actividad, descubierto en el Estado de Chiapas" (*Memorias y Rev. Acad. Nacl. de Ciencias "Antonio Alzate,"* Vol. 53, 1931–1932, Mexico, 1934–1936, pp. 411–416) Dr. F. K. G. Müllerried reports on his discovery and examination of a volcano and an extensive zone of rock of volcanic origin in northern Chiapas, Mexico. His attention was first attracted to the region in 1928 when, on the road from Pichucalco to Ocozocoautla, he noticed a high mountain east of the road that, from its form, appeared to be of volcanic origin in spite of the fact that thitherto the formations of the region had been described as sedimentary. In 1930, earthquakes having been felt in the region and a volcanic eruption reported, he was commissioned by the Universidad Nacional Autónoma and other coöperating institutions to investigate. His original conclusion proved true: the mountain seen in 1928 is a volcano in solfataric state, called locally El Chichón, from the fruit of the palm *Astrocaryum mexicanum* Liebm., found growing in abundance in the forests covering its slopes. In form the volcano is a flattened cone, its longer diameter (running northwest-southeast) measuring 5.5 kilometers. The crater is oval, its longer diameter measuring 1900 meters. The lowest point of the crater was some 945 meters above sea level; peaks on its border reached as high as 1315 meters. Steam and sulphurous fumes issuing from crevices and several thermal springs testified to the solfataric state of the volcano.

A zone of rocks of volcanic origin of which El Chichón is the active center extends

from the neighborhood of Ciudad Las Casas to the Sierra de San Andrés Tuxtla in a direction about N 55° W. This zone is about 350 kilometers long and 100 kilometers wide. It appears to be completely isolated, inasmuch as the nearest volcanic formations on the west are in the western part of the state of Oaxaca and on the east it is separated from the volcanic system of Central America by the Sierra Madre of Chiapas, with its crystalline, intrusive, and schistose rocks.

EUROPE

A New Atlas of the Free City of Danzig. The Free City of Danzig, with its territory of 754 square miles (about three-quarters of that of Rhode Island), occupies a highly critical position on the map of Europe. Many facts of interest concerning this small region and its external trade relationships are set forth on 29 attractive colored maps (mostly 1 : 300,000) and discussed in the accompanying text of a recent little atlas (Nikolaus Creutzburg: Atlas der Freien Stadt Danzig, Danzig, 1936; see also Eugene Van Cleef: Danzig and Gdynia, *Geogr. Rev.*, Vol. 23, 1933, pp. 101–107).

Most of the Free City's territory is a part of the delta of the Vistula, a miniature Holland, with dikes, polders, canals, and drainage ditches, whose intricate geometrical patterns are effectively illustrated on one of the maps. The region is unlike Holland, however, in that transportation and travel are predominantly by land, only the large distributaries of the Vistula being used for water shipments. Reclamation of the marshes as well as of a considerable area below mean sea level has been in progress since the Middle Ages. Until as late as 1888, however, the polders were subject to disastrous floods, a danger that appears now to have been eliminated.

Although many of the villages in this lowland and on the glacial moraines and sandy tracts to the west are compact strassendorfs, other forms are also represented, and between the villages there are scattered farms. The scale of the map showing types of rural settlement is so large that each village carries a separate symbol, and the complexity of the picture suggests that generalized maps purporting to show the distribution of village types over wide areas may be misleading, at least for parts of Europe.

Dot maps showing the number of people according to languages spoken in 1923 and the distribution of votes at elections in 1920 and 1933 indicate that the region is overwhelmingly German in speech and political sentiment. Poles constitute a noteworthy element only in Danzig and its suburbs, and even there they are no more than a small minority. Danzig, however, depends mainly on Poland for its continued existence as a seaport.

The volume of maritime commerce passing through Danzig declined from 8,600,000 tons in 1928 to about 5,100,000 in 1935. That of Gdynia, the rival Polish port only about eight miles away, has increased, and in 1933 for the first time Gdynia took the lead; in 1935 the total tonnage handled there was about 7,300,000. Four ingenious maps of Europe show Danzig's commerce by means of flow lines of different widths. Most of the exports consist of coal from Upper Silesia en route to Scandinavia, France, and Italy and of wood from eastern Poland and the Carpathians bound for Great Britain and to a lesser extent for the Netherlands, Belgium, and France. The volume of imports is only about one-sixth that of the exports. The imports, mainly iron ore, sulphur, fertilizers, herrings, and manufactures, are destined almost exclusively for the progressive districts of Poland that formerly belonged to Prussia, and also for Warsaw and Czechoslovakia; a mere trickle penetrates the more primitive central and eastern regions of the Republic.

The Use of Building Materials in Poland. A colored map (1 : 1,000,000) of an unusual type accompanies a recent study by Dr. Stanisław Gorzuchowski (Osiedla miejskie w Polsce i ich material budowlany w zależności od czynników przyrody,

Warsaw, 1936; with French résumé: Les habitats urbains en Pologne et leurs matériaux de construction en rapport avec le milieu naturel). It shows the building materials used in "urban habitats" in Poland. The definition of "urban habitats" has been made sufficiently broad to include not only the larger towns but also many small nonagricultural settlements. For each of 1365 places a black-and-white symbol indicates the relative number of buildings made of wood, clay, stone, or brick. For purposes of comparison the most important brickyards are located and also forested areas and areas where local building stones are exploited. A less detailed map showing the use of building materials in the villages of Poland is reproduced in Dr. Gorzuchowski's article entitled "Some Aspects of Rural Poland" in L. A. Boyd's "Polish Countrysides" (*Amer. Geogr. Soc. Special Publ. No. 20*, 1937), page 106, as adapted from a map by Wiktor Ormicki (*Wiadomości geograficzne*, Vol. 7, 1929, pp. 94–96).

In the parts of Poland that formerly belonged to Germany brick prevails. On the treeless plateaus of Podolia, where the steppes extend westward into Polish territory, there is widespread use of clay or adobe. Local building stones together with wood are employed on the central uplands between Cracow and Warsaw. Throughout by far the greater part of the country, however, the predominant material is wood. This is true even of the larger cities of the north and northeast, with the exception of Warsaw. Sixty per cent of the buildings in Łódź are wooden, 85 per cent in Bialystok, 70 per cent in Grodno, 80 per cent in Wilno, but only 30 per cent in Warsaw.

AFRICA

Ecological Study on the South African Coast. The coasts of the Union of South Africa are very imperfectly known ecologically. This is the more regrettable since not only are the conceptions of the biology very largely based on studies in higher latitudes (except for studies of coral reefs) but the presence of cold water, the Benguela Current, along the west coast and of warm water, Mozambique and Agulhas Current, along the east and south coasts (compare this number of the *Geographical Review*, pp. 651–664) makes the South African shores unusually interesting. The more welcome then is the plan for a series of studies of "The South African Intertidal Zone and Its Relation to Ocean Currents." The first contribution under this title, with the subtitle "A Temperate Indian Ocean Shore," by T. A. Stephenson, Anne Stephenson, and C. A. du Toit, appears in the *Transactions of the Royal Society of South Africa* (Vol. 24, 1936–1937, pp. 341–382). The series is to extend from Durban, where "the influence of the warm current is so strong that reef-corals are present," to Port Nolloth, where "the effect of the cold water is in full force." This first paper deals with Still Bay (34° 23′ S., 21° 25′ E.), west of Mossel Bay.

Although no temperature data are available for Still Bay, the writers are able to indicate the temperature status of the bay by noting the presence or absence of species characteristic of localities of warmer and colder sea temperatures. It is intended to deal with this matter in greater detail in a subsequent paper, but some tentative and preliminary remarks are made. Still Bay shows marked differences from localities along the west coast, especially in the absence of large kelps, which are characteristic of that coast. As compared with the subtropical fauna and flora of Isipingo, near Durban, the tropical elements in the fauna and flora of Still Bay are not absent, but they are not enough in evidence to affect the general appearance of the shore. False Bay has a still smaller tropical element than Still Bay and also a larger cold-water element. The conclusion is that Still Bay is "a place with . . . a climate lying towards the warmer end of the temperate scale." The conclusions are illustrated by a brief account of the distribution of limpets. They might also have been illustrated by a more explicit consideration of the algal flora of South African coasts.

The most valuable contribution of this first paper lies in the delimitation and definition of the intertidal zones. The subdivision is based on the distribution between tide levels of certain animals that are sedentary or show only slight movement from place to place. The authors stress the existence of many resemblances between the temperate Indian Ocean shore, as exemplified by Still Bay, and the coasts of the British Isles. For example, on both shores there are periwinkles at high levels, areas with closely packed barnacles, and the massed tubes of marine worms at lower levels. The species, however, are different. Although the difference afforded by the absence of kelps at Still Bay is mentioned, the writers do not emphasize the contrast so far as the seaweed vegetation is concerned.

WM. EDWYN ISAAC

ASIA

Studies in Syrian Geography. As a result of more than fifteen years of the French mandate, French scholars have gradually been publishing studies on the geography of Syria. Many of these are the work of M. Richard Thoumin, two of whose regional studies are here reviewed: one on the Ghab and one on southern Syria.

Conflict between Assyrians and Moslems in 'Iraq has led the British to seek a place to which these Christian war refugees from Turkey may be moved. One locality being considered is the Ghab, a marsh district northwest of Hama, in Syria, for which the French have been considering a reclamation project. A recent article describes this region after the fashion of French studies on rural habitat (Richard Thoumin: Le Ghab, *Rev. de Géogr. Alpine*, Vol. 24, 1936, pp. 467–538).

The Ghab is a complex graben, through which flows the Orontes River. Resistant outcrops form several temporary base levels. In winter it is a lake some 12 to 18 miles long, but in April or May the waters recede and the reeds reappear, to remain until November. Changes in water level of 24 to 32 inches cover or expose hundreds of acres. In antiquity there was an important rural population in the district, especially during the Seleucid period; but after Byzantine rule was withdrawn, insecurity, plus earthquakes affecting public works, forced transportation routes to move farther east, and the area declined. Greater security has increased settlement in the last century.

At present the population is about 30,000, divided into four main groups. Nearly a third are descendants of the old sedentary population. These live in five villages on the south margin, on the edge of the plateau of Hama, where there are the best sites for security and for cultivation. There they grow some barley and wheat on the slope down from the plateau; they also raise livestock (sheep and water buffaloes). Most of them are Christians; a few are Sunnite Moslems. The inhabitants of the few Mawali villages form a second group. In the seventeenth century the Mawali were the Bedouin masters of the Syrian steppe, but by the nineteenth century they had been driven west by the invading Shammar and Anaizeh tribes. Wealthy landowners of Hama get the Mawali amirs to furnish laborers for their borderlands; these tribesmen, the poorest members of the tribe, stay from two to ten years until they can save enough money to buy some livestock, and then they return to the tribe. The inhabitants of the marsh villages, along the right bank of the Orontes, are descendants of nomads deported from the Euphrates Valley by the Turks about 1800; in addition there are a few Mawali and Banu Khalid tribesmen who were expelled from their tribes as a result of internal quarrels. The villages are built on elevations in the marsh, sometimes each hut on a separate tiny island. The villagers obtain a livelihood by raising water buffaloes, fed on marsh pastures, by fishing (with three-tined spears), and by cultivating small kitchen gardens. Land is owned by the state, which levies no tax but which hires the natives to catch certain kinds of fish for sale in the urban markets. The fourth group, the Nusairis, are the latest to settle. Formerly residents of the Jebel el Ansariye (western border

of the Ghab), where the steep eastern fault face is too poor for subsistence on even a Syrian level, they began settling along the left bank of the river some seventy-five years ago when the Turks cut down the raiding necessary to provide minimum supplies. Their way of life imitates that of the marsh folk.

In this article M. Thoumin emphasizes physiography, origin of settlement, and house types in the manner characteristic of many recent French studies. The American geographer would like to see a few more statistics, but these are well-nigh impossible to obtain in Syria.

M. Thoumin's latest monograph, "Géographie humaine de la Syrie centrale" (Arrault et Cie., Tours, 1936), is of primary importance. This describes and analyzes southern Syria in the manner of French regional studies and shows especially the influence of the method of the late Professor Jean Brunhes. The author's aim is "to describe and explain the facts of human geography" and examine the "adaptation of man to the physical environment." This aim is carried out in so thorough and illuminating a fashion that the book is of value not only for the study of the geography of Syria but also for the advanced study of geographic principles.

As it is the result of eight years of field work (1924–1931), the study contains numerous observations that are the distillations of the years of contact and analysis. The quality of the writing is excellent; the thought is clearly and simply presented, without verbosity. Consistently M. Thoumin emphasizes the importance of regional and local contrast, especially as regards particularism. For example:

"Contrast is no less between social groups, since traditions and diverse ideals have developed following divergent and sometimes opposed aspirations. The characteristics appropriate to sedentary peoples living in relations with nomads mark the peoples of the interior. With them flocks count among the essential factors of economic life and the fear of razzias remains a constant anxiety; wisdom confounds itself willingly with a distrust toward every innovation, and the possibility of irrigating land is held as the principal wealth and the best of blessings. In the districts of the west the Lebanese participate in the qualities and aptitudes of Mediterranean peoples; relations with the foreigner and commerce in all its forms attract them. The guaranties of security given them by the relief of the mountains and the treaties of the powers have accustomed them to full liberty; they receive with joy the ideas and inventions arrived from Europe, open a commission house, or go to try their luck in America to gain wealth."

By "Central Syria" the author means the southern part of French Syria, but he excludes from it the plateau proper, the Homs area, and the Hauran (Jebel ed Druz) as being separate regions. In his description and analysis this area is subdivided into six regions: the eastern piedmont oases, Kalamoun, Mt. Hermon, the Anti-Lebanon Mountains, El Beqa' (Rift Valley), and the Lebanon Mountains. In the text the author consistently discusses first the desert edge and last the Lebanon.

The material is organized into five parts: Physical and Historical Factors (30 pages), The Division and Distribution of Water (81 pages), Land Utilization (57 pages), Communications and Transportation (33 pages), and Human Settlements (138 pages). The last section is devoted chiefly to an analysis of site factors, population densities, and house types. The regional population-density maps are of particular interest.

Another recent study, by an economist, analyzes the port development and the economy of Syria (Jacques de Monicault: Le port de Beyrouth et l'économie des pays du Levant sous le mandat français, Librairie Technique et Économique, Paris, 1936). Half of the book is devoted to a study of the port of Beirut and its competitors, their history, equipment, communications, and trade. In 1934 Beirut handled 61 per cent of the foreign trade of Syria, whereas the three ports of Tripoli, Alexandretta, and Latakia handled about 30 per cent. The author defends the development of Beirut as the only port with modern equipment by saying that

Syria's annual foreign trade by sea is 600,000 to 700,000 tons, whereas a trade of 400,000 to 500,000 tons is necessary to support adequate modern facilities in a port. He considers that the future of the port of Beirut is linked rather closely to the development of the transit trade serving 'Iraq and Persia. The British have developed Haifa into an important competitor, though the distance to Baghdad is 1220 kilometers from Haifa and only 990 from Beirut.

The rest of the book deals with the various aspects of Syrian economy. The discussion of agriculture is most interesting. The French estimate the cultivable area of Syria at 5,790,000 hectares; in 1919 only about 700,000 hectares was cultivated, but in 1934 this had increased to 1,230,000 hectares, an increase of 75.7 per cent. This expansion has been brought about through the establishment of security, the development of roads and canals, the expansion of credit, the consolidation of landholdings, tax reform, and tariff protection. Statistics on crop area and production and yield to a hectare are also given. Some manufacturing is developing, but not much. The mandatory government is actively encouraging the tourist industry of Syria both as a summer resort for the residents of near-by areas and as a winter resort for Europeans.

Although certain minor defects are noticeable—a number of typographic errors; no index or maps—the good points of this little treatise make it of definite value in the study of the geography of Syria. The use of statistics, mostly for the period 1927–1934, is remarkable: these are usually omitted as unavailable. An appendix includes the texts of the Treaty of Lausanne, the mandatory agreement, etc. This is the first serious study of French achievements in Syria seen by this reviewer.

J. Allen Tower

Further Developments in the Field of Geography in China. In the July, 1936, number of the *Geographical Review* George B. Cressey called attention to the progress being made in China in geography and tributary fields. The present note is concerned with further developments. Conspicuous progress is being made in pedagogical publications by universities and colleges. Under the direction of the Geography Department of the National Central University, Nanking, a monthly magazine, the *Geographical Education*, has been published since April, 1936. It is similar to the *Journal of Geography* of the National Council of Geography Teachers in the United States. A similar monthly magazine, the *Geographical Teaching*, is published by the Department of Geography of the Peiping Normal University. Ginling College, Nanking, of which the writer is a member, is the only mission institution of higher education that has a geography department at present. At the request of the East China Christian Educational Association the department prepared in the spring of 1936 "A Bibliography of Recent Literature on Geography" for high-school teachers of geography and revised it in February, 1937. The department has also begun publication of an annual containing articles of general geographical interest. Among the articles in the first (1936) number that attract special attention are, for example, interpretations of climatic proverbs and the part played by climate in politics.

Other new magazines are the *Geologic Critic*, a bimonthly begun by the Geological Society of China in the spring of 1936, especially designed for the general reader; and the *Meteorological Magazine*, successor to the *Bulletin of the Meteorological Society of China*, which was published twice a year up to July, 1935, and since then has been published as a monthly. The *Geographical Journal*, the quarterly of the Chinese Geographical Society, Peiping, is one of the earliest geographical publications of China. Formerly it emphasized the historical side of geography; the last number of 1936 announces a new program along the line of modern geographical thought.

The National Institute for Compilation and Translation has published (1936) a detailed study on the Yellow River, in three volumes dealing respectively with

meteorology, geology, and hydrology. In addition to the soils publications mentioned by Professor Cressey (see above), reference should be made to *Soil Bulletin No. 13*, "A Soil Survey of Tinghsien, Hopei Province" (1935), a detailed study of the characteristics and distribution of soils representative of the alluvial soils of the North China plain; *Soil Bulletin No. 14*, "A Study of the Shantung Soils" (1936); *Soil Bulletin No. 15* (1936), which contains an article "pH Values and Lime Content of the Soils of China" and a study of some saline soils; and *Soil Bulletin No. 16*, "Soils of Yungning, Kwangsi" (1936), the only available detailed account of the soils of that province. There is also the important "Geography of the Soils of China," by James Thorp, published by the National Geological Survey of China in 1936. The 16 chapters deal with the geographical background, the soil-forming processes, the great soil groups, crops and soil fertility, soil erosion in China, and soils and the people. The book is illustrated with many clear and characteristic photographs and is accompanied by a fair-sized map; it has a long bibliography, a glossary of soil terminology, and appendixes furnishing a list of important plant species of China and notes on methods of analysis.

Of interest to the geographer is "The Land Classification of Kiangsi, Anhwei, Honan and Hupeh," by W. R. Swen, R. C. Tsui, and A. B. Louis of the Department of Agricultural Economics of the University of Nanking for the Farmers' Bank of China. Among other things this publication discusses the relations between quality of land and economic conditions and future farm development in connection with loan policies.

In the national program for rural reconstruction the experimental counties keep in close coöperation with the learned institutions. The New Rural Reconstruction Program in Tsining County in Shantung is a notable example. There the county is actually turned into a laboratory. Professors and students of such institutions as Yenching University and Tsing Hua University, Peiping, Nankai University, Tientsin, and the University of Nanking, Nanking, are all doing actual service there as a part of their college program; even Peiping Union Medical College is doing her health-work training there. Although there is no formal geography on the program, there are many geographical problems that are vital and form the basis for the reconstruction program. Because of the lack of available geographers the work is now carried on jointly by agriculturists, sociologists, economists, and engineers. However, the demand for geographers is increasingly urgent.

LIU EN-LAN

Contrasts in the Progress of Industrialization in China and Japan. The rapidity of developments in Japan in the last few years throws into even greater relief the extraordinary contrasts in the industrial history of the two great Oriental powers. In an article with the above title John E. Orchard (*Political Sci. Quart.*, Vol. 52, 1937, pp. 18–50) considers this "enigma," "the result of many conflicting and interacting forces—prejudice and superstition, cultural tradition, the old economic system, political conditions," fundamental to which is "the contrast in the geographic background of the two countries—small size and compactness as opposed to a large area and diversity, insularity against continentality." Japan yielded to Western influence because she had to; the only solution for her helpless situation was "wholesale and immediate adoption of all that the West had to offer." But this was not the whole story. Even before Commodore Perry's visit the internal economy of the country was breaking down; acceptance of industrialization was no less a means of internal salvation. China, on the other hand, had an established economic order that had served for centuries and was still going, even if not too smoothly. Confidence in her size and ultimate capacity of absorption has been an inherent part of the philosophy of China. The unity of China, an amazing unity in view of regional diversities and lack of communications, has always been cultural

rather than political. One powerful bond, as Professor Orchard points out, has been the system of civil-service examinations, a democratic institution that, remaining virtually unchanged from its foundation in the second century of our era to the end of the nineteenth century, gave the country a common written language. In Japan the ending of feudalism found an entire class, the samurai, robbed of occupation. With the aid of the government they contributed largely the means of the economic reconstruction of the country.

In addition to Chinese antagonism and apathy, there have been many tangible and positive hindrances to industrialization; for example, the foreign control of tariffs until 1929 and the hampering effect of a cumbersome and unstable currency (Japan, on the other hand, adopted a gold basis shortly after embarking on her industrial career). Scarcity of capital, legal concepts which do not comprehend corporation organization and in which banking and credit structure rests on personal rather than institutional relations, the restrictions and rigidity of the ancient guild systems all are unfavorable to modernism. Equally as important is political instability. "China includes numerous nuclei of population, each isolated from the others by topography and by distance, and each possessing its own economic identity, its own leaders and its own political ambitions. With any weakening of the ruling dynasty, the conflict of regions and economies, north against south, coast against interior, nomad against sedentary agriculturist, has inevitably followed until some area or faction has emerged victorious to rule until it in turn is displaced. Under the circumstances, the wonder is not that China has had so much political disturbance but that any national identity remains."

Now, in these last few years, awake to the dangers of Japanese expansion, the Chinese attitude has changed: "there is a visible turn to mechanization and modernization as possible solutions of China's present predicament." Professor Orchard's expression is emphasized by Étienne Dennery in an article "Problèmes d'Extrême-Orient: Les changements récents dans l'équilibre économique des puissances en Extrême-Orient" (*Ann. de Géogr.*, Vol. 46, 1937, pp. 337–368). At this time, when difficulties in China are greater than ever before, an earnest effort is being made at reconstruction. Most progress has been made in means of communication, especially roads: where there were only 1185 kilometers of roads in 1921, there now (1936) are 109,749. The costlier railway development has not been so fast, but there are now (1935) 15,000 kilometers; and there are 18,000 kilometers of airways.

But industrial progress in China is feeble beside that in Japan. The rapid progress of Japan since 1930 has been made, not under the encouragement of favoring external circumstances (as in the World War), but under a government policy that seeks in expansion a remedy for internal difficulties, and economic expansion goes hand in hand with territorial expansion. Gains have been made by organization (in 1931 a Major Industry Control Law was passed), which permits modern and highly efficient techniques. There have been great increases in cotton, rayon (Japan is now the world's second largest producer), wool, glass (third largest producer), and rubber; but, as the "Japan-Manchoukuo Year Book" for 1937 puts it, "especially noticeable has been the animation shown by the heavy industries through the effects of 'national emergency.'" In 1936 for the first time Japan became self-sufficient in steel.

Associated with the gains in industry have been gains in new markets; Japanese entry into new fields has caused worry to other industrial nations. However, M. Dennery sees a new trend in Japanese business, a trend toward "valorization of empire." Korea and Formosa have become increasingly important markets for Japan; they took 24 per cent of her exports in 1935. Still greater efforts are being made to increase trade with Manchukuo and North China. "The concept of an economic bloc of Japan, her colonies, Manchuria, and even North China has made rapid progress in the mind of Nippon. Its application presupposes, in large meas-

ure, the adoption of a system of closed economy and the sacrifice, by Japan, of a part of her export to other nations. . . . The *rapprochement* with the great European protagonist of autarchy, Germany, may equally well encourage Japan to follow this course."

POLAR REGIONS

Bottom Deposits of the Ross Sea. "Bottom Deposits of the Ross Sea," by H. C. Stetson and J. E. Upson (*Journ. of Sedimentary Petrology*, Vol. 7, 1937, pp. 55–66), presents the results of a mechanical and mineralogical analysis of 12 cores obtained by S. Edward Roos as a part of the oceanographical work carried out on the *Bear* (compare pp. 574–583 of this number of the *Review*). Ten of the cores were obtained along the front of the Ross Shelf Ice; the other two were taken farther north on the 180th meridian.

The authors conclude that "the type of sediment which surrounds Antarctica is, as far as is known at present, unique among marine deposits." The material is a heterogeneous mixture of coarse and fine particles, remarkably uniform in character across the 300-mile-wide zone, not only in the Ross Sea area but, so far as can be determined from the older analyses of other expeditions, throughout the entire terrigenous border of the Antarctic Continent. The chief characteristics of the minerals of the deposit are their freshness, the angularity of the grains, and the relative abundance of the heavy minerals as a whole and the ferromagnesian group in particular. No minerals were found that could not have derived from observed types of rocks. "They are the same as those reported by Gould from the Queen Maud Mountains." Pebbles and boulders brought up by the dredge and examined megascopically were similar to the fragments in the cores. The deposit is essentially the product of a continental ice sheet. It has all the characteristics of a till laid down on land. This is more striking if the Antarctic deposit is compared with deposits from Arctic waters. Samples from Davis Strait obtained by the *Marion* expedition show a much sandier deposit and much better sorting of material. Here there are other sources of sediment besides glacial bergs, and currents exert a selective action on deposition. Samples from the Arctic Basin proper, like the Antarctic deposits, show unusually large amounts of clay and colloid but, unlike them, show good sorting. The Arctic has no bergs of glacier ice. River deposits on landfast ice subsequently broken up and distributed constitute the larger part of the sedimentary material.

PHYSICAL GEOGRAPHY

Submarine Canyons. The attention that is being given to submarine canyons of the continental shelf has probably raised a question in the minds of many of those interested concerning the nature and accuracy of the material available for this study. The reasonable accuracy of methods recently developed by the United States Coast and Geodetic Survey has been outlined by Paul A. Smith (The Accuracy of Soundings and Positions Obtained by Methods Used in the United States Coast and Geodetic Survey, *Trans. Amer. Geophys. Union, Sixteenth Ann. Meeting, April 25 and 26, 1935*, Washington, 1935, Part 1, pp. 9–14). He states that the error of soundings may be within 1 per cent in depths of 10 to 200 fathoms and within 3 per cent in depths greater than 200 fathoms. For position, where visual-fix ranging near the shore is feasible, the error ranges from 1 : 500 to 1 : 1000; out of sight of land, where radioacoustic ranging is used, the error may range from 1 : 200 to 1 : 500. Such accuracy is remarkable. Privately conducted surveys in which a hand reel was used have been described by F. P. Shepard (Detailed Surveys of Submarine Canyons, *Science*, Vol. 80 (N.S.), 1934, pp. 410–411; see also his "Canyons off the New England Coast," *Amer. Journ. of Sci.*, Ser. 5, Vol. 27, 1934, pp. 24–36). There

is therefore the beginning of an accurate base map on which submarine geology can be delineated (see also pp. 625–636 of this number of the *Review*).

Successful dredging has been carried on in the canyons of the Atlantic coastal plain by H. C. Stetson (Geology and Paleontology of the Georges Bank Canyons. Part I, Geology, *Bull. Geol. Soc. of America*, Vol. 47, 1936, pp. 339–366) and off the California coast by Shepard. Both succeeded in breaking fragments of rock from the canyon walls. In 1934 Stetson obtained samples of coarse sandstone, greensand, and indurated silt ranging from Upper Cretaceous to late Tertiary in age from the steeper walls of Georges Bank canyons. In the summer of 1935 Shepard (Geological Mapping of the Ocean Bottom, *Science*, Vol. 82 (N.S.), 1935, pp. 614–615), using similar dredging equipment, obtained fragments of rock ranging probably from Eocene to Pleistocene in age from five canyons off the California coast. Of 15 canyons examined up to this year, 12 showed rocky walls, some even granite. The presence of fossils in many of the samples means that identification need not rest on purely lithological grounds.

A radical improvement in methods of sampling the softer bottom deposits, whereby cores more than eight feet long can be obtained in deep water, has been developed by Piggot (C. H. Piggot: Apparatus to Secure Core Samples from the Ocean-Bottom, *Bull. Geol. Soc. of America*, Vol. 47, 1936, pp. 675–684; "Core Samples of the Ocean Bottom," *Carnegie Instn. News Service Bull.*, Vol. 4, 1936, pp. 83–87). It should furnish results of great importance. The refraction seismograph has been adapted to work at sea down to 100 fathoms (Maurice Ewing, A. P. Crary, and H. M. Rutherford: Geophysical Investigations in the Emerged and Submerged Atlantic Coastal Plain, Part I, Methods and Results, *Bull. Geol. Soc. of America*, Vol. 48, 1937, pp. 753–802). The surface of the crystalline basement beneath the Atlantic coastal plain (presumably corresponding in part to the Fall Zone peneplane) has been traced from the inner margin of the coastal plain to the edge of the continental shelf. Near the edge the crystalline basement lies beneath 12,000 feet of less consolidated material; the abyssal slopes of the ocean are some 4000 feet higher. As a result of this work, according to Miller (B. L. Miller: Geophysical Investigations in the Emerged and Submerged Atlantic Coastal Plain, Part II, Geological Significance of the Geophysical Data, *ibid.*, pp. 803–812), we can be fairly certain that the submarine canyons of the Atlantic coastal plain are entirely incised in rocks of Mesozoic or Cenozoic age.

A rather full statement of the canyon problem and its historical background up to 1933 was made by Shepard (F. P. Shepard: Submarine Valleys, *Geogr. Rev.*, Vol. 23, 1933, pp. 77–89). He has, however, as a result of later data (see below), apparently partly abandoned the theory developed there. More recently Smith has enumerated field studies and theories suggested (P. A. Smith: Submarine Valleys, *U. S. Coast and Geodetic Survey Field Engineers Bull. No. 10*, 1936, pp. 150–155). At the risk of repetition, some of the major theories advanced in the last four years are reviewed here.

In 1934 Davis (W. M. Davis: Submarine Mock Valleys, *Geogr. Rev.*, Vol. 24, 1934, pp. 297–308) proposed that, where shore-line topography is favorable for localized ocean currents, outward-flowing bottom currents compensating inward drift of surface water might develop or keep open submarine valleys. "It is possible that the shore waters, made turbid . . . [at times of severe onshore winds] by wave action, would thus gain an increased specific gravity that would facilitate their descent into the colder water of the depths." Whereas Davis made no point of this increased density and treated it as an accessory circumstance, there is a similarity here to the density current later suggested by Daly.

Whereas Davis considered processes going on today, Daly (R. A. Daly: Origin of Submarine "Canyons," *Amer. Journ. of Sci.*, Ser. 5, Vol. 31, 1936, pp. 401–420) suggests canyon cutting under special conditions during the Pleistocene. The theory,

in brief, demands a 300-foot eustatic drop of sea level during formation of the ice-caps. Most of the continental shelves were then exposed. The waters, weighted with sediment from the mud banks on the outer margins of the shelves and from rivers, slid down the continental slope, thus producing a density current. Concentration of current action in preëxistent irregularities of the slope led to excavation of the canyons. Daly's theory has received the support of Kuenen (P. H. Kuenen: Experiments in Connection with Daly's Hypothesis on the Formation of Submarine Canyons, *Leidsche Geol. Mededeelingen*, Vol. 8, 1937, pp. 327–351). Shepard discusses aspects unfavorable to this theory (F. P. Shepard: Daly's Submarine Canyon Hypothesis, *Amer. Journ. of Sci.*, Ser. 5, Vol. 33, 1937, pp. 369–379).

Stetson has reviewed the problem of subaerial and submarine origin of the canyons, discussing subaerial processes in greater detail, but at the time of writing did not consider the evidence warranted complete rejection of either view. He has tested currents in the Georges Bank canyons and demonstrated that normal tidal currents are not significant as an erosive agent.

Hess and MacClintock (H. H. Hess and Paul MacClintock: Submerged Valleys on Continental Slopes and Changes of Sea Level, *Science*, Vol. 83 (N.S.), 1936, pp. 332–334) have put forward the hypothesis that, possibly under the influence of some stellar body, the rotation of the earth was suddenly decreased and a rapid change in the shape of the hydrosphere resulted, depressing sea level in low latitudes and raising it in high latitudes, though the authors themselves point out that a sudden change in the speed of rotation is a formidable objection to overcome. Shepard has raised additional objections (F. P. Shepard: Submerged Valleys on Continental Slopes and Changes of Sea Level, *ibid.*, pp. 620–621). A. C. Veatch also has considered a theory taking into account the influence of a stellar body (see Smith, Submarine Valleys, p. 154), in which a change in the lithosphere may have taken place.

In 1936, on the basis of recent Russian investigations, Shepard (F. P. Shepard: The Underlying Causes of Submarine Canyons, *Proc. Natl. Acad. of Sci.*, Vol. 22, 1936, pp. 496–502) suggested the formation of an enormous dome-shaped icecap about four miles thick over the entire Polar Regions and a greatly extended Antarctic icecap. This, according to his figures, would lower sea level some 3000 feet. Before glaciation there were depressions of the continental slope resulting partly from diastrophism, landslide, and the submergence of true river valleys by diastrophism in an earlier period. Recession of the sea by 3000 feet during formation of the icecap allowed rivers to flow out over the exposed shelf into preëxistent depressions of the slope and excavate canyons to the level of the sea.

The problem is surrounded with difficulties. Objections have been raised regarding the efficacy of submarine currents. For the most part the submarine canyons do not suggest faulting or collapse of solution channels. If the canyons are entirely of subaerial origin, the shelves of the world may have been uplifted some 8000 feet or more sometime since late Tertiary, maintained temporarily during stream cutting, and again depressed. In the light of existing knowledge this is hard to accept. The ocean bottom may have been depressed. Field (R. M. Field: Structure of Continents and Ocean Basins, *Journ. Washington Acad. of Sci.*, Vol. 27, 1937, pp. 181–195) suggests that "there may have been profound, local, Quaternary movements in the basin itself; and that these movements may have affected ocean level, especially if there were coincident movements in the floor of the Pacific." We are then faced with the necessity of reëlevating the ocean bottom in order that sea level may again resume approximately its former position. Water may have been removed from the ocean to form great icecaps. The recent suggestion of a 3000-foot eustatic drop in this way does not account for the lower 3000 to 5000 feet of canyon. But we have greatly improved techniques for obtaining information, and considerable enthusiasm is being shown by workers in this comparatively new field.

Change in Submarine Topography off the Queensland Coast. Information obtained by comparison of soundings made by British survey ships in 1869 and 1904 apparently recorded profound deepening of the ocean bottom off the northeast coast of Australia. This was interpreted by Hedley as representing actual crustal changes in an active earthquake zone, by David and others as excavation of the sea floor by powerful marine currents. It is discussed in one of the last papers by Professor William M. Davis (Submarine Mock Valleys, *Geogr. Rev.*, Vol. 24, 1934, pp. 297–308). Davis, after correspondence with the British Admiralty, was assured of the reliability of the surveys. Although he ascribed the deepening tentatively to degradation by sea-floor currents, he suggested that confirmation of this change should await a third survey. In 1927 the area was resurveyed by the *Moresby*. W. H. Bryan (The Supposed Deepening of the Sea Floor off Breaksea Spit, *Repts. Great Barrier Reef Committee*, Vol. 4, Part 2, 1936, pp. 45–50) summarizes our present knowledge concerning this supposed change. He was informed by the Admiralty that " 'it does not appear to be safe to deduce that the differences in the various versions of the 100-fathoms line is due to changes in the sea-bed; there is far too great an element of doubt as to the accuracy of the earlier surveys, and . . . the "Moresby's" work is the only survey which gives, or has ever given, an accurate picture of the sea-bed.' " Furthermore, comparison of existing sounding data with earthquake records shows that during the first period of supposedly great bottom deepening no earthquakes were reported in the region. During the period of supposedly little bottom change a major earthquake was reported (1918). Seismograph records show a variation of 120 miles in the position of its epicenter as well as discrepancy in the direction. Bryan, in summation, notes that "all theories purporting to explain these alleged changes are gratuitous" and suggests that the only way to ascertain ocean-bottom changes is by a resurvey and comparison with that of the *Moresby*.

Genesis of Bermuda Atolls. Processes of active shore-line erosion on Bermuda, according to Henri Prat (Les formes d'érosion littorale dans l'archipel des Bermudes et l'évolution des atolls et des récifs coralliens, *Rev. de Géogr. Physique et de Géol. Dynamique*, Vol. 8, 1935, pp. 257–283), can be limited to the zone between the shoreward boundary of land vegetation and the submarine limit of massive-coral growth. The mechanical erosion of waves, the chemical honeycombing effect of spray above the wave limit, and the fortuitous exposure of limestone caverns tend to favor the processes of shore-line retreat. Water temperature rarely falls below 16° C., whereas air temperature often drops to 8° and even at times to 0°, with the result that completely submerged organisms have more truly tropical affinities. Prat finds that massive corals (*Porites*, *Maeandra*, etc.) are unable to survive where uncovered at low tide. In contrast with this condition, massive corals of the Great Barrier Reef are found to "live for very long periods, regularly undergoing the usual tidal exposure" (F. W. Moorhouse: The Cyclone of 1934 and Its Effect on Low Isles, With Special Observations on Porites, *Repts. Great Barrier Reef Committee*, Vol. 4, Part 2, 1936, pp. 37–44; reference on p. 43).

Two genetically different types of atoll are described, one related directly to shore-line retreat, the other to temperature-controlled upward limit of massive-coral growth. Those constituting the former (*type régressif*), locally known as "boilers," are the remnants of small islands isolated from the coast during its retreat and leveled by wave erosion to about low-water level. Composed largely of ancient wind-blown limestone, they are preserved from complete removal by massive incrustations of mussels and similar organisms along their periphery. The central basin, incapable of supporting such life adequately and left exposed to continued destructive processes, is not built up. Massive corals play no part in the construction of this type. The other type (*type progressif*) is the direct product of active submarine expansion of massive-coral reef builders. Prat finds from experiments that massive forms are

extremely susceptible to the rate of water renewal. Furthermore, they are limited in upward expansion by the water temperature. Thus, as the best reef builders expand outward along the margins, the reefs attain a certain dimension where modified living conditions and inadequate water renewal force their disappearance from the central part. Wave action further accentuates this process by heaping up broken coral fragments along the periphery.

A Variation of Wegener's Hypothesis. Geologic evidence indicates that climate in many parts of the earth has changed radically during geologic time. Wegener cited this evidence as strong support of his hypothesis of continental drift. In a recent article (Structure of the Earth's Crust and the Spreading of the Continents, *Bull. Geol. Soc. of America*, Vol. 47, 1936, pp. 1587–1610) Beno Gutenberg agrees that continental masses seem to have changed their positions with relation to the poles in the course of geologic periods. However, he does not subscribe to the concept that continents broke apart and drifted in the subcrust like icebergs in a sea; he reiterates his *Fliesstheorie*, first announced about ten years ago, which postulates slow plastic flowage both in the continental masses and in the subcrust. The principal points in Gutenberg's argument are as follows:

Seismic data now available indicate clearly that the Atlantic and Indian Oceans and also the southwestern part of the Pacific Ocean are floored with rock that resembles in its elastic properties the rock of the continental masses. By the same kind of evidence, the greater part of the Pacific Ocean and much of the Arctic Sea are known to have floors of another material, probably basaltic rock. Gutenberg suggests that the granitic rock, or sial, is 40 to 50 kilometers thick in most parts of the continents and not more than 20 kilometers thick under the Atlantic, Indian, and southwestern Pacific Oceans. Thus the light continental rock is continuous from the Americas on the west to Europe and Africa on the east; and separation of these continents, strongly suggested by geologic facts, must have occurred by plastic flow. A series of sketch maps, repeated without change from Gutenberg's earlier paper (Die Veränderungen der Erdkruste durch Fliessbewegungen der Kontinentalscholle, *Gerlands Beiträge zur Geophysik*, Vol. 16, 1927, pp. 239–247, and Vol. 18, 1927, pp. 281–291), show the northward movement of the continents since Carboniferous time, the result of which is that areas once in the warm temperate zone are now within the Arctic Circle (for example, Spitsbergen) and lands that were subject to late-Paleozoic glaciation in high southern latitudes are now near the tropics (for example, South Africa and Australia). In addition to the northward "flow," there was spreading of the sialic crust both eastward and westward toward the Pacific, resulting in progressive separation of the continents in the western hemisphere from those in the eastern hemisphere. As evidence that this spreading is still in progress Gutenberg cites the circum-Pacific belt of earthquake epicenters.

Regardless of the reader's reaction to the *Fliesstheorie*, Gutenberg's paper is valuable because it reviews the results of recent geophysical investigation and suggests interpretations that have important geologic bearings. A section on deep-focus earthquakes is of particular interest. Shocks originating at depths of several hundred kilometers have been taken to mean either that stresses originate suddenly, as in an explosion, or that the strong crust extends to great depths. Gutenberg suggests that the zone of deep-focus earthquakes is without strength, but great viscosity permits accumulation of large stresses within a few years. On both sides of the Pacific the belt of deep-focus epicenters lies farther landward than the belt of shallow shocks. Gutenberg fits this arrangement into his *Fliesstheorie*, since the shallow-focus earthquakes can be attributed to flowage of the continental crust toward the ocean and those of deep focus to compensating flow in the opposite direction at great depth.

CHESTER R. LONGWELL

HUMAN GEOGRAPHY

The Provisioning of France in Fats and Oils. To what extent can the needs of France in foodstuffs and industrial raw materials be met by her great colonial empire, the second greatest in the world today? An essay at answering this question is made by M. Jean Gottmann in "Mémoire sur l'approvisionnement de la France en matières premières et grandes denrées alimentaires" (*Mémoire Français No. 7, Conference Permanente des Hautes Etudes Internationales, Xème Sess., Paris, 1937*. Institut Internatl. de Coopération Intellectuelle, Paris, 1937). His conclusions are discouraging to dreams of autarchy; for he considers that France must remain in strict dependence on the foreigner for a large part of her imports. M. Gottmann surveys the general field, with the aid of summary tables, but he gives special consideration to the fats and oils of vegetable origin (France uses comparatively little imported animal fat: she is, it may be noted, nearly self-sufficient in butter). In 1935 France imported 556,768 tons of oil (total animal and vegetable fats expressed in terms of oil) and exported 120,542 tons—amounts representing a deficiency of 436,226 tons. Although the use of oleaginous substances has increased for industrial as well as for alimentary purposes, production in western Europe has declined. Fifty years ago France produced four times as much olive oil as she does now; in fact, today she can meet little more than a quarter of her requirements. Imports come as seeds or expressed oil. The five chief imported seeds are peanuts, flaxseed, copra, palm kernels, and castor beans; in the form of expressed oil, olive and palm. Soybean seeds and cottonseed are of surprisingly little importance.

Of the imports, the French colonies produce (by weight) four-fifths of the palm kernels, nearly half the peanuts, one-seventh of the copra and sesame, one-eighth of the castor oil, an insignificant amount of flaxseed, and 85 per cent of the palm oil and olive oil. For the decade 1926–1935 the average was 32 per cent by weight, 26 per cent by value. Peanuts come shelled or unshelled. In 1935 the two forms came in nearly equal proportion; but, whereas the bulk of the unshelled nuts came from French West Africa, only one-sixth of the shelled nuts came from there and more than half from India. The shelled nuts yield 40 per cent of oil, as against 30 per cent from the unshelled nuts. In 1934 French West Africa obtained favoring measures from the government in addition to duty-free import into the mother country, and the export of shelled nuts began and has made rapid progress—the amount in 1936 was nearly double that in 1935. Palm kernels and palm oil come almost entirely from French West Africa; but the situation is quite otherwise with copra, of which six times as much comes from foreign sources as from the colonies. French Africa has lately had an overproduction of palm products, and it has been suggested that palm oil might be substituted for coconut oil where technological processes permit. But—and here is a typical instance of the difficulties that "artificially" stimulated production runs into—there are certain objections. The oil content of copra is 63 per cent, as against 45 per cent for the palm. It is already difficult to dispose of the palm-oil-cake by-product, and the oil is inferior in quality. Flaxseed comes in small amounts from Morocco, but in the French import of this product Argentina has a virtual monopoly. Most of the castor oil—so important for airplane motors—comes from India. Madagascar and French West Africa, the present colonial producers, might possibly meet requirements under a strong protective tariff, but the costs would be greatly increased. And this is true of the situation in oils and fats in general.

HISTORICAL GEOGRAPHY

Some Recent Publications in the Field of Medieval Geography. The first seven parts of Prince Youssouf Kamal's "Monumenta cartographica Africae et Aegypti," a comprehensive collection of geographical and cartographical source materials

relating to ancient and medieval Africa and Egypt, were reviewed in this journal some years ago (*Geogr. Rev.*, Vol. 24, 1934, pp. 175–176). Since then four new parts have been published, carrying the treatment down to the early years of the fourteenth century. In the Monumenta the documents are presented without editorial comment, but Prince Youssouf discusses points of interest in connection with some of them in two smaller publications: "Quelques éclaircissements épars sur mes Monumenta Cartographica Africae et Aegypti" (Leiden, 1935) and "Hallucinations scientifiques (Les portulans)" (Leiden, 1937). The latter is a critical consideration of certain vexed questions relating to the portolan charts. Professor J. H. Kramers of the University of Leiden, one of the scholars who has collaborated with Prince Youssouf and Dr. F. C. Wieder on the Monumenta, has suggested that the makers of the first portolan charts may well have been strongly influenced by the Arab geographers, particularly El-Bakri and Edrisi. One might expect an Egyptian scholar, prompted by national sentiment and pride in the Moslem heritage, to welcome this hypothesis; but Prince Youssouf is too sound a scholar to allow such considerations to affect his judgment. He regards as "scientific hallucinations" not only Professor Kramers' hypothesis but also the widely held view that it was primarily to the dissemination of the mariner's compass that the origins of the portolans may be traced. Indeed, in his opinion, the question of how these remarkable charts first came into being is likely to remain unanswered.

To the *Geographical Review* for October, 1933 (Vol. 23, pp. 621–638), Professor Paul Kahle contributed a paper entitled "A Lost Map of Columbus," dealing with a Turkish chart of the Atlantic Ocean of the early sixteenth century by Piri Reis. An inscription on this chart (which was first brought to light in 1929) states that certain names, shore lines, and islands were copied from a map by Christopher Columbus; and Professor Kahle in his paper attempted to reconstruct the characteristics of a lost Columbian map from the information thus supplied. A magnificent colored facsimile of Piri Reis' chart, measuring about 35 by 25 inches, with a transparency furnishing a transliteration of the Turkish inscriptions and an accompanying text in Turkish, German, English, and French by Yusuf Akçura, president of the Society for Turkish Historical Research, has recently been published (Piri Reis haritasi hakkinda izahname, Türk Tarihi Araştirma, *Kurumu Yayinlarindan No. 1*, Constantinople, 1935). The reproduction was made at the suggestion of President Kamâl Atatürk and does credit to the Devlet Basimevi (Government Printing Establishment), which executed it.

The history of the early exploration of Greenland, the medieval settlements there, and the Vinland voyages are surveyed, with useful bibliographical references, in a recent paper by Professor Henry S. Lucas (Mediaeval Economic Relations between Flanders and Greenland, *Speculum*, Vol. 12, 1937, pp. 167–181). Except as regards trade in walrus tusks in the early fourteenth century, Professor Lucas finds little firsthand information concerning commercial connections between the Flemish towns and Greenland. However, on the basis of evidence now available he concludes that we may "confidently hold that commerce was carried on more or less uninterruptedly during the five last centuries of the Middle Ages [ca. A.D. 1000–1500] between Greenland and . . . [Europe]. And we can assert with equal confidence that as Flanders was a chief focal point of commercial and industrial activity in northwestern Europe it inevitably has some direct or indirect share in the trade with Greenland."

French Activities in Acadia and Louisiana at the Turn of the Seventeenth Century. "Acadia at the End of the Seventeenth Century," by J. C. Webster (*New Brunswick Museum Monographic Ser. No. 1*, St. John, N. B., 1934), makes available for the first time several letters and memoirs written mainly by Joseph Robineau de Villebon, who represented French authority in Acadia during the last decade of the seventeenth

century. "Acadia" is used in its contemporary sense, including the New Brunswick mainland, with which the memoirs deal more largely than with the Acadia of a later time. Only a few of the memoirs seem likely to be of direct usefulness to geography, though the whole collection contributes to an understanding of this period when it seemed advisable to French authority to continue an aggressive policy against New England both by sea and by land. Perhaps the most significant memoir is Villebon's account of the coast fishery of Acadia in 1699. A folded map by Dr. W. F. Ganong, for a quarter of a century an authority on the historical cartography of maritime Canada, shows the mainland seigniories, most of which were granted after 1672. Dr. Ganong has stated elsewhere that only a few of these grants were actually settled as planned and that the system as a whole, at least in old Acadia, was a failure.

In reading Maurice Ries's "The Mississippi Fort, Called Fort de la Boulaye" (*Louisiana Hist. Quart.*, Vol. 19, 1936, pp. 829-899) one can sense the exultation of four men who, after many years of intermittent search, finally discovered the presumable site of this fort mentioned in documents in the 1700's. According to the author, the site is on the left bank near Phoenix, La., 50 miles from the mouth of the river. The vestiges are few enough—a cannon ball and "two small pieces of cypress log"—but adequate, in the opinion of several individuals who have filed affidavits in the Parish of Orleans, to establish this as the site of the old fort. Statements that this may have been "the first French settlement in Louisiana" and "the most important French historical site in America" have many parallels in the local histories of "Louisiane" and New France.

RALPH H. BROWN

GEOGRAPHICAL AIDS

The Classification and Cataloguing of Geographical Materials. The schemes of classification used in general and university libraries include many topics of no geographical interest; they make no provision for many geographical topics; and many of their headings and subheadings tend to scatter through the stacks just the materials that the geographer would wish to find together in one place. Although indispensable for many purposes, the conventional dictionary catalogue, in which the cards are arranged alphabetically by authors, titles, and subjects, leaves much to be desired as an aid to geographical research.

For this reason special methods of classification and cataloguing were long ago devised for use in geographical libraries in Europe and also for the classification of items in geographical bibliographies. Reference may be made, for example, to the admirable classifications found in the *Geographisches Jahrbuch*, the *Bibliographie Géographique Internationale*, and Paul Dinse's printed "Katalog der Bibliothek der Gesellschaft für Erdkunde zu Berlin: Versuch einer Systematik der geographischen Literatur" (Berlin, 1903). Each of these contains two main divisions: in one the items are arranged systematically by topics; in the other they are arranged by regions or areas. In 1923 the American Geographical Society inaugurated its "research catalogue," a special card catalogue covering all current accessions of books, maps, and pamphlets and important periodical articles and manuscripts. This is a classed catalogue, likewise divided into two main parts, topical and regional, and it now contains references to some 85,000 items. The classification, based in part on that of Dinse and in part on a study of the actual fields of interest that geographers cultivate, has been expanded since 1923 in the light of current trends in geographical research. With certain notable modifications and improvements the Society's catalogue forms the basis of the recommended scheme presented by S. W. Boggs in his recent report as chairman of the committee on library classification and cataloguing of the Association of American Geographers (Library Classification and Cataloging of Geographic Material, *Annals Assn. of Amer. Geogrs.*, Vol. 27, 1937, pp. 49–93).

This report should be of value not only to librarians concerned with geographical materials but to all geographers faced with the problem of filing notes. In the main body of the report a clear discussion is given of principles and of technical matters pertaining to the shelving of publications and to the making and arranging of cards. This discussion is supplemented by two appendixes, in which the recommended subject and regional classifications respectively are set forth in detail in tabular form. By scanning the items listed in the subject classification (which is almost identical, except for notation, with that of the American Geographical Society's research catalogue) the student may gain some conception of the broad scope of modern geography.

Two New Encyclopedias. Lucien Febvre, professor of the history of modern civilization at the Collège de France, is known to geographers through his "La terre et l'évolution humaine: Introduction géographique à l'histoire" (Paris, 1922; English translation: A Geographical Introduction to History, London and New York, 1925; see *Geogr. Rev.*, Vol. 13, 1923, pp. 147–148, also p. 146). In this substantial and scholarly work hasty generalizations in the field of human geography are scathingly criticized. Professor Febvre is editor in chief of the great "Encyclopédie française," now appearing in separate parts. His critical knowledge of the trend of geographical studies in France and his sympathy for what is best and soundest in geographical research may give assurance that geography will be adequately represented in the new encyclopedia.

"L'Encyclopédie française" is arranged systematically rather than alphabetically. When complete, it will comprise 21 magnificently illustrated volumes, of which 4 have already been published: "L'Espèce humaine" (Vol. 7), "L'État moderne" (Vol. 10), and "Arts et littératures" (Vols. 16 and 17). The volume on the human species, edited by Paul Rivet, is a summary of modern anthropology, ethnography, ethnology, and demography, by many contributors. A survey of the ethnography of the principal peoples of the world and chapters on population movements are of geographical interest. In his introduction Professor Febvre writes: "L'ennemi, c'est le simplisme." Oversimplified generalizations concerning race have been the bane of anthropological studies, and many French historians have gone too far in stressing racial origins. Febvre maintains, however, that "race has been expelled from the whole field of [French] national history. To reintroduce it, no matter what the pretext, would be for us Frenchmen to step backward intellectually."

"Handwörterbuch des Grenz- und Auslanddeutschtums" (Ferdinand Hirt, Breslau, begun in 1933), to which 800 collaborators are contributing under the editorial direction of Professors Carl Petersen and Otto Scheel and others, will fill five volumes when complete. To date, the first volume and a part of the second have been received at the American Geographical Society. As the title implies, this encyclopedia is devoted to the German populations of the borderlands of Germany and Austria and in other non-German territories all over the world. The articles, alphabetically arranged, consist of the biographies of outstanding personalities and discussions of specific topics such as "race," "nation," and "population problems" and especially of regions both large and small, including cities. The regional articles are exceptionally detailed for controversial areas in Europe like the Banat, the Burgenland, and the Polish Corridor, where a large number of Germans now dwell under foreign rule. To the Banat, for example, no fewer than 78 closely printed pages are devoted, together with some 23 statistical, political, and historical maps. Five pages have to do with Chicago, and there are even articles on Albany and Buffalo; in these, statistics and other information are presented regarding the peoples of German stock and German enterprises of all kinds. A map shows the distribution of German churches in Chicago. Brief details about the scientific work of the Baltic Germans under the Russian regime and about German missionary

activities will be found in an article on Alaska. All in all, this publication, with its comprehensive bibliographical references and clean-cut maps, is a work that no serious student of political or social geography can well afford to overlook.

GEOGRAPHICAL NEWS

The International Geographical Congress of 1938. The International Geographical Congress of 1938 will be held in Amsterdam, The Netherlands, from July 18 to 28 inclusive. Information on the Congress is available in two circulars issued in March and July, 1937, by the Organizing Committee, Professor J. P. Kleiweg de Zwaan, chairman, and Captain E. J. Voûte, secretary, and in a report (a free translation of the first circular) by the National Committee of the United States. The United States Committee, of which Mr. W. L. G. Joerg is chairman, holds itself in readiness to render professional assistance to American geographers planning to attend the Congress.

Membership in the Congress is open to geographers, members of geographical associations, and persons professionally connected with institutions and organizations whose field of work bears on geography. The membership fees, which should accompany the application blank, are: regular members, 12½ florins; associate members, including members of the families of regular members and students of geography recommended by their professors, 5 florins. Prospective American participants may obtain application blanks from the National Committee of the United States, International Geographical Union, in care of the Division of Geology and Geography, National Research Council, 2101 Constitution Avenue, Washington, D. C.

The program of the Congress includes the presentation and discussion of the reports of the special commissions nominated at the 1934 (Warsaw) meeting, of papers by members on a restricted list of topics, and geographical excursions. The special commissions deal with mapping of Tertiary erosion surfaces; Pliocene and Pleistocene terraces; climatic variations; the geography of population and of the rural habitat; publication of old maps; and photographic air mapping. The chosen topics are: *Cartography:* (1) Adaptation to photogrammetry of the methods of map representation, especially the representation of topography, specifically by means of contours. (2) Use of aerial photography in the rapid reconnaissance mapping of relatively unexplored areas. (3) Questions in the field of map projections. (4) Presentation of cartographic works. *Physical Geography:* (1) Glacial erosion. (2) The problem of piedmont terraces. (3) The problem of terminal moraines. *Oceanography:* (1) General circulation of the oceans. (2) Internal oceanic oscillations. (3) Submarine relief, especially of the southern hemisphere. *Human Geography:* (1) Present migration movements and the influences that affect them. (2) The functional relations between urban agglomerations and the countryside. (3) Social advantages and disadvantages of home industry (or part-home, part-factory industry) for an agricultural population under given geographical conditions. *Economic Geography:* (1) The industrial development of maritime ports. (2) The qualitative and quantitative relationships of different means of transportation in general and in each country in particular. (3) Is it possible to express in a relatively precise way, by means of numerical indices, the productive value of soil and climate so as to determine the comparative economic value of different countries? *Colonial Geography:* (1) The possibilities of white colonization of the tropics. (2) The relation between population density and method of land utilization (or exploitation) in colonial regions. (3) Industrialization as a condition indispensable to the maintenance of a satisfactory standard of living in tropical countries of dense population. *Historical Geography and History of Geography:* (1) History of the geometry of the earth and of geographical localization. (2) In-

fluence of the Renaissance on geography in relation to the revival of the study of Ptolemy. (3) Doubtful and disputed points in the interpretation of maps, more particularly of those of the Age of Discovery. *Geographical Landscape:* (1) The concept "landscape" in human geography. (2) The analytical study of the structure of the landscape as a basis for the study of habitational, agricultural, and industrial occupance. (3) In modern civilization what are the principles on which the preservation of the beauties of the landscape should be based? *Methodology and Education:* (1) The value of the teaching of geography in the establishment of friendly relations among nations. (2) What topics in physical geography should form part of the geographical curriculum, and how far should they be developed? (3) Advantages and disadvantages of the Dalton method in the teaching of geography.

Papers must not be more than 10 printed pages in length (number of words not specified), and they may be submitted in any one of the official languages of the Congress—Dutch, English, French, German, Italian, and Spanish. Papers will not be read by their respective authors, but each paper will be presented in a critical *compte rendu* by a reporter designated for each topic. Authors will, however, have the opportunity of making brief explanatory comment. The papers will be printed in full and distributed before the Congress; hence the Secretariat emphasizes the necessity of receiving the papers not later than January 1, 1938. (Address of the Secretariat: Koloniaal Instituut, Mauritskade 63, Amsterdam, The Netherlands.)

In addition to short excursions during the Congress, there will be longer excursions before and afterwards as follows: Zeeland, July 11–16; the mining region of the Netherlands, July 29–August 3; the dunes and polders, July 29–August 1; Rotterdam and environs, July 28–31; the glaciated region, July 29–31; the former Zuider Zee, July 29–30; the Dutch East Indies, leaving Amsterdam on August 3 and returning to Marseilles on October 11.

GEOGRAPHICAL REVIEWS

Japan's Population Problem

Ryoichi Ishii. **Population Pressure and Economic Life in Japan.** xix and 259 pp.; indexes. P. S. King & Son, Ltd., London, 1937. 12s. 6d. 9 x 6 inches.

During the past ten years there has been a growing appreciation, not only in Japan but in America and Europe, of the many serious problems, social, economic, and political, created by Japan's increasing population; and several discussions have appeared. To the literature of the subject Dr. Ryoichi Ishii has made a valuable contribution. His volume "Population Pressure and Economic Life in Japan" presents no conclusions not already reached by Western scholars, but it is more comprehensive than any other work on the subject in English. It has the great virtue of dependence on source material in the Japanese language; and the author is able to make a more critical use of Japanese census data than could a Westerner limited to the more abridged English versions of the official publications.

The volume falls naturally into three parts. The first three chapters are introductory. They present a résumé of the population trends before 1868, the date of the restoration of the emperor to power and a convenient beginning date of Japan's modern period; and they trace the transition that has occurred in Japan in the modern period and the effect of the economic changes on the population trend. It is Dr. Ishii's opinion that the stationary population of the later Tokugawa period was due mainly to the restriction of families through the practice of infanticide and abortion and that the rapid increase in numbers in more recent years is explained by the government's efforts to stamp out such practices, efforts that met with little success until increased economic opportunities were afforded by the rapid industrialization following the Sino-Japanese War.

In the second group of three chapters the population estimates of the earlier years of the modern period and the quinquennial-census data, first collected in 1920, are critically examined. From a statistical analysis of sex and age distribution, marriage and divorce rates, and birth and death rates Dr. Ishii concludes that the Japanese population will reach a total between 80 and 90 million by 1960—an estimate corroborated by other Japanese students—and that about 500,000 will be added annually to the Japanese working population, whose increase is the most serious aspect of the population problem.

The remaining chapters discuss the possible solutions of Japan's population problem. Dr. Ishii finds little hope in agriculture and expects that the consolidation of holdings and the introduction of more mechanical methods will accelerate movement from the land to the urban areas. He very properly points out that the real food problem of Japan is not a shortage of supply, since ample quantities of rice can be obtained from Korea and Formosa to supplement the product of Japan proper. The development of these colonies, however, has created a serious dilemma, for which no solution has yet been found. Japan needs the colonial rice, but it is produced at costs lower than the agricultural costs in Japan and has a depressing effect on the price of rice in Japanese markets. If it is admitted freely to Japan, it will aggravate further the already deplorable conditions of the Japanese rural population; if its import is restricted, there will be serious repercussions in the colonies, and the cost of living of the Japanese industrial workers will be raised. Japan faces the dilemma of an imperialistic nation seeking to develop its colonies for food and raw materials as a basis of its own industrialization and at the same time depending on agriculture as a principal occupation to the extent of almost one-half of its population.

In these concluding chapters colonization and emigration, industrialization and

birth control are examined as possible solutions of the population problem. It is in industrialization that Dr. Ishii sees the greatest hope, provided that industrialization proceeds inside the limit of a well measured plan geared to afford exports acceptable in the present restricted state of world trade and provided there is a "re-evaluation of the social system, looking toward an improvement in the distribution of the national income."

For the most part Dr. Ishii is quite objective in his approach to even the most controversial questions; but he allows himself to become unduly optimistic regarding the outlook for Japanese colonization in Manchukuo, and he dismisses too readily the poverty of raw materials as an obstacle to Japanese industrialization. A serious omission is an adequate discussion of the powerful competitive advantage in world trade possessed by Japan in the crowding numbers that constitute her population problem.

JOHN E. ORCHARD

SOUTHERN AFRICA FROM THE HISTORICAL VIEWPOINT

A. P. NEWTON AND E. A. BENIANS, edits. **The Cambridge History of the British Empire, Vol. 8: South Africa, Rhodesia and the Protectorates.** xxv and 1005 pp.; maps, bibliogr., index. The Macmillan Co., New York; The University Press, Cambridge, England, 1936. $11.00. 9½ x 6½ inches.

This massive volume is the result of the collaboration of two dozen eminent authors, each a specialist in some period or aspect of history, several of them also prominent South African statesmen. Yet the editors seem to have accomplished successfully the difficult task of ensuring balance and continuity of narrative and eliminating serious duplication. In reviewing the work from the geographical point of view the first duty is to record with satisfaction that the two opening chapters have been allocated respectively to Professor P. Serton ("The Geographical Environment") and Professor I. Schapera ("The Native Inhabitants"). Professor Serton has contrived, in nineteen pages and three maps, to present all the leading facts that might be expected to bear on the history. But it must be added that few of the historical writers have made more than passing allusion to geographical circumstance. Yet the reader is properly prepared to appreciate the reasons for the strategic and commercial significance of the Cape during the first two centuries of its occupation. He is shown that no other point than the Cape was so suitable as a refreshment station for the East Indian trade. The Portuguese system of crossing the Indian Ocean aided by the reversing monsoons, like that of the Arabs before them, did not encourage their use of the Cape. The Dutch, on the contrary, with their direct crossing of this ocean where widest, required such a port of call. St. Helena, their earlier station, lay halfway for the sailor from Batavia to the English Channel: but the Dutch East India Company in 1649 sought a port that would serve equally for the outward voyage; and this was Table Bay, for the better harbor of Saldanha Bay was without fresh water.

The local peculiarities of the swift Agulhas Current are described as they affected the early sailing routes and affect even modern steamer routes south of Africa. In dealing with the factors influencing the spread of Europeans from the Cape Professor Serton summarizes the physical causes of slow communication by ox wagon and slight contacts in view of the typically large stock farm of 6000 acres; and so the reader is led to appreciate the revolutionary effect of railway building, a subject that is developed in the chapter on "Economic Development, 1795–1921," by Professor Arnold Plant. In discussing the vegetation Professor Serton alludes to the significance of the word "veld" as indicating a cover more or less fit for pasturage; and the varied applications of the name to different vegetations according to the point of view of the user are described. Foreign geographers might with advantage note

this authoritative South African explanation of puzzling divergences of usage. Attention is properly drawn to the lack of valid evidence of climatic change despite conflicting reports of early travelers. But one of the most permanent features of the climate is its variability. Lack of space doubtless restricted to inadequacy the reference to those man-created processes the results of which simulate those of climatic change—lowered water table, erosion, deterioration of vegetation, etc. Dr. C. W. de Kiewiet, however, makes further mention of these matters later in the book.

Professor Schapera presents very satisfying descriptions of the Bushmen, Hottentots, and Southern Bantu from the point of view of the social anthropologist. Incidentally, many nontechnical readers will learn with interest of the now established fact that the Bushmen were not the first stone-implement users in South Africa. It may be useful to mention here a more recent publication relating to these peoples, the purpose of the article of course being quite different. In his paper on remnant folk and refuge lands (Restvölker und Rückzugsgebiete in Südafrika, *Mitt. Seminars für Orientalische Sprachen in Berlin*, Vol. 39, 1936, pp. 46–110) Dr. Gerhard Henrich makes use of much the same kind of materials but develops a more geographical point of view. His long bibliography is also worthy of note.

The narrative of discovery is begun by Professor E. H. Warmington in "Africa in Ancient and Medieval Times," a straightforward account in which the reader is given a clear understanding of the reasons why the south and southwest coasts of Africa remained undiscovered by Mediterranean and Arabian sailors. The Portuguese discoveries are then admirably treated by Professors Edgar Prestage and A. P. Newton. But there the formal effort to describe the exploration comes to an end; and we are left to presume that the interior of the subcontinent, except for the Cape region and the Karroo, remained virtually unknown until the beginning of the Great Trek, in 1835. Before this, three reconnaissance parties were sent respectively into Southwest Africa, northeastern Transvaal, and eastern Natal; they reported unfavorably on the first region but very favorably on the others. Were these, then, the first reliable reports of the hinterland? Did not the earlier wandering hunters or the ivory traders of the eastern frontier record what they had seen? Such are questions that occur to a geographer.

The references to geographical facts and influences throughout the main part of the work are, as indicated above, more sporadic than geographers would like; but with a fair knowledge of the territory and the use of a good atlas one may "read more geography into" the text. For example, there is abundant treatment of the extension of European settlement and of the nature of conflict with, and subsequent restrictions on, the spread of the natives. Geographers will be able to supply from other sources a more detailed picture of the types of land involved in each case. Moreover, in order to see the geography of the Union as it is in true perspective, they will do well to utilize fully the sources now published and especially to read the chapter on economic development, by Arnold Plant, and that on "Social and Economic Developments in Native Tribal Life," by Dr. C. W. de Kiewiet.

ALAN G. OGILVIE

TROPICAL AFRICA AS A SOURCE OF RAW MATERIALS

LEO WAIBEL. **Die Rohstoffgebiete des tropischen Afrika.** 424 pp.; maps, diagrs., bibliogr. Bibliographisches Institut, Leipzig, 1937. RM 18. 10 x 7 inches.

Students of the geography of Africa have long awaited Professor Waibel's newest volume. By way of introduction 50 pages are devoted to the tropics in general, and this introduction is followed by a historical survey and a geographical bird's-eye view of tropical Africa. Then the individual regions are studied—the cultural and economic status of the natives and the influence on native life of the impact of European industrialization and the plantation system.

The struggle for a place in the sun, or at least for products from tropical regions, is very old. As can be seen from the hieroglyphics in her temple at Deir el Bahri, Queen Hatshepsut (1495–1475 B.C.) sent to Punt (the tropical shores on both sides of the Red Sea and the Somaliland Peninsula) five sailing vessels laden with rings, necklaces, weapons, and food supplies, to be bartered for incense, ebony, gold, ivory, leopard skins, and slaves. This is a classic example of trade between an industrialized state and a region of tropical raw materials—an early example of a geographical division of labor. From the status in Egyptian days Professor Waibel proceeds to the penetration of Africa by the Romans, by the Arabs during the Middle Ages, and by the Europeans from 1500 on. Several pages are devoted to the slave trade from 1500 to 1890 and to the development of the plantation system.

Part 3, the main body of the book, deals with the *Rohstoffgebiete*, the regions producing raw materials. The natives raise peanuts, coffee, cotton, and tobacco on small plots and aim at self-sufficiency. The unconsumed surplus is sold and enters the world market. The Europeans favor the plantation system. Sisal hemp, cotton, coffee, tea, tobacco, cane sugar, coconuts, and bananas are produced on a large scale, almost exclusively for international trade. A world-wide depression in prices may throw out of work thousands of natives, who have forgotten how to be self-sufficient. The natives have suffered detribalization and a general social disintegration, without new social mores to take the place of the old. This problem confronts whole regions in Africa today. The farm economy of the East African highlands is discussed and also the white settlements in the healthful highlands of Angola.

By way of conclusion 20 pages are devoted to the trade of tropical Africa. Cacao, palm oil and kernels, and cotton were, in the order named, the most important export products in 1933, sugar, palm oil, and peanuts in 1870. The three principal imports are textiles, iron and steel products, and *Genussmittel* (sugar, tea, coffee, and tobacco).

In this volume Professor Waibel not only brings up to date the treatment of the tropical areas in Karl Dove's "Wirtschaftsgeographie von Afrika" (1917), but he treats them in greater detail and with a broader outlook. His work is not merely an economic geography of tropical Africa. It is a brilliant and fascinatingly written synthesis of the economics, sociology, history, and, in some measure, the political science of that region. Indeed, "the disciplines of history and geography are in the main to be distinguished merely by the difference in treatment of time and place." It is to be hoped that Professor Waibel will be able to carry out his project of doing for tropical Asia and America what he has so successfully done for Africa.

RAYMOND E. CRIST

THE COLD WATER REGION OFF SOUTH WEST AFRICA

ALBERT DEFANT. **Das Kaltwasserauftriebsgebiet vor der Küste Südwestafrikas.** Maps, diagrs. In "Länderkundliche Forschung: Festschrift zur Vollendung des sechzigsten Lebensjahres Norbert Krebs," Stuttgart, 1936, pp. 52–66.

For his study of the region of upwelling off the coast of southwestern Africa Defant has had surface and subsurface observations at his disposal. Böhnecke's charts of the surface temperatures show along the coast in each month of the year an area of negative anomaly, which in the summer of the southern hemisphere is found farther south than in winter. Interesting and new are Defant's representations of the surface currents, which in each month show a one-sided line of divergence running nearly parallel to the coast and following the temperature-anomaly curve of about −3° C. Between the coast and the divergence line the surface currents are directed parallel to the coast; outside the line they are directed more to the west. Vertical sections based on the *Meteor* data and running nearly at right angles to

the coast show that inside the divergence line the isotherms and isohalsines, which at greater distances from the coast are nearly horizontal, bend toward the surface. They indicate upwelling motion, which, however, does not bring water to the surface from depths greater than about 200 meters.

Defant points out, as Helland-Hansen has done, that the presence of cold and heavy water near the surface off the coast does not imply that upwelling takes place, since, if in the southern hemisphere a current runs north along the coast, the heavy water must be accumulated on the coastal side. Defant emphasizes, however, that a transversal circulation is necessary in order to maintain low surface temperatures. The prevailing southeast wind maintains the general flow and the transversal circulation. Taking into account the effect of the wind on a sea in which the density increases with depth, Defant arrives at the conclusion that at some distance from the coast outside the divergence line a swirl with horizontal axis must be present in the nearly homogeneous upper layer. The water below this swirl flows toward the coast, where it ascends toward the surface inside the divergence line and thus gives rise to a horizontal temperature distribution similar to the vertical distribution found between depths of 100 and 200 meters at a distance of about 500 nautical miles from the coast. Inside the divergence line the distribution of density causes a current parallel to the coast. Defant finds that the results of dynamic computations confirm his conception; but this does not seem quite clear to the reviewer, since the computations indicate strong currents parallel to the coast both inside and outside the assumed divergence line.

The reviewer wishes to take exception to the opinion expressed by Defant that the phenomena of upwelling are of similar nature in other areas. The simplicity of Defant's picture may be due to his use of average surface conditions and widely spaced subsurface data. Gunther's detailed study of the Peru coastal current and recent work off the coast of southern California undertaken by the Scripps Institution of Oceanography have indicated that the upwelling is an intermittent process and that the transversal circulation is more complicated than Defant assumes.

H. U. SVERDRUP

INDIAN FOREST TYPES

H. G. CHAMPION. **A Preliminary Survey of the Forest Types of India and Burma.** x, 286, and viii pp.; maps, ills., bibliogr., index. *Indian Forest Records*, Vol. 1 (N.S.), No. 1, Delhi, 1936. 17s. 6d. 9½ x 7½ inches.

This compilation by the Silviculturist of the Forest Research Institute at Dehra Dun has been prepared to meet the need for a standard classification of Indian forest types. It is based on reports by provincial silviculturists and on the author's twenty years of observation and reading. It is best described in the author's own abstract: "A classification of forest types is put forward based on four temperature zones, tropical, subtropical, temperate and alpine, each subdivided on available moisture as reflected by the relative importance of evergreen, deciduous and thorny trees. Whilst the form of the tropical forests is similar on both sides of the Tropic of Cancer, the flora is considered sufficiently different to render subdivision into northern (quasi-subtropical) and southern variations advisable. Omitting moist and dry alpine scrub, 13 formations are distinguished, seven of them subdivided into northern and southern variations. The 6 tropical formations are subdivided into 33 forest types, most of which are admittedly composed of several associations, these being indicated when possible; important edaphic variants (24) are listed, and successions are discussed leading to the recognition of 12 primary and 10 secondary important seral types. Subtropical and temperate forests are similarly dealt with. For each type is given a general description of the forest and the locality factors, plant lists for typical

examples, and ecological notes. Many types are illustrated by photographs and references are given to published illustrations for the rest." It should be added that there are two maps of India and Burma, showing climax vegetation types and rainfall on a scale of 1 : 18,000,000.

The geographer will find this a useful reference work, and he will be interested in the introductory discussion of factors determining forest types. Mr. Champion warns against too "rigid interpretation" of the types. "Climate as we have seen is composed of a great many factors simultaneously at play and all attempts at a formula for an arrangement in a single series have failed to meet requirements." Among formulas discussed is that of Thornthwaite of which Mr. Champion remarks: "This classification despite its limitations agrees with the distribution of the main vegetational types, and should be worth working out in greater detail."

A Hungarian Festschrift

Cholnoky Jenő, ünnepi füzet (Cholnoky Anniversary Volume of the Hungarian Geographical Society). Maps, diagrs., ills., bibliogrs. *Földrajzi Közlemények*, Vol. 63, No. 8–10, 1935, pp. 149–452.

The miscellaneous character of the collection of articles in this volume, produced in honor of the thirtieth anniversary of Professor Eugene Cholnoky's appointment to a university professorship, reflects the wide range of Professor Cholnoky's own investigations, as the bibliography of his published works shows.

The leading article of this collection, by Professor Cholnoky's friend and colleague Count Paul Teleki, discusses the migrations of nomadic peoples from the steppes of Central Asia, an area that the author himself had explored in collaboration with Professor Cholnoky. Count Teleki finds that the various particularistic hypotheses, such as the theory of the desiccation of Central Asia, fail to offer a satisfactory explanation, and he seeks to develop an organic view of the total situation out of which each migration arose. In all migrations of peoples many factors are involved, both of "push" and of "pull," arising from both the human and the physical environment. Each migration is a unique combination of these many factors, and its explanation must be sought in relation to its spatial and temporal setting.

Count Teleki's contribution to the theory of migrations offers little that is new to American students The principal value of his paper lies in his incidental treatment of the stages of transition between the nomadic and the agricultural economies. Out of his wealth of personal experience in these "zones of transition" Count Teleki describes the symbiotic relationships between the nomads and the settled peoples of the oases. He points out that the process of "settling down" is long and gradual and that it frequently involves a shifting back and forth between the two economies.

In the second article of this collection Dr. Rezső Milleker criticizes the well known ethnographical maps of Hungary. Even their name is a misnomer, since their purpose is to show the location of nationality groups. Dr. Milleker attacks the customary marking of large areas as uninhabited. Pastures and forests supply a livelihood to the citizens of many communes. Landownership, he contends, must serve as the basis of any map giving an accurate picture of the distribution of nationalities. In the case of cities, he holds that there is needed a map detailed enough to show the distribution of residents by nationality, occupation, and economic status. In contending for greater accuracy in map construction Dr. Milleker has become aware of the need for such a technique as that employed by Howard Whipple Green in dealing with the cultural areas of the city of Cleveland. By such means the correlation between various aspects of the life of the residents of detailed areas may be shown.

In the third article, "The Hungarian Flora and Its Soil," Gyula Prinz asserts that the desertic character of the Hungarian Alföld has been generally overestimated.

In support of this hypothesis Prinz defines an "actual desert" as one "created by climatic aridity," a phenomenon not found in Hungary. He admits that much of the Alföld readily becomes a desert through the drifting of sand or the emergence of natron salt. Such deserts, however, according to this author, are not "actual deserts," since "nothing would stand in the way of afforestation." Actual observation of desert regions of the Alföld, such as the Sóstó of Szeged, prevents a ready acceptance of this assumption. In fact, throughout this article dogmatic statements are used to give summary dismissal to highly controversial questions, such as that of the rapid spread of natron deserts in the Alföld since the draining of the basin. For Prinz this issue is settled with the statement: "People hold that water regulation is guilty of this but it is a natural phenomenon."

In his article "Formes de terrain en Hongrie" Dr. Stephen Györffy points out that, unlike the settlement patterns of western Europe, those of Hungary were determined by the size, shape, and arrangement of the lots. Two distinct types of lot are found: the cone-shaped lot of the pastoral people of the Alföld and the ribbonlike lot of the agriculturists of the hilly regions. The Alföld pattern reflects a temporary encampment of nomads. A group of three or four lots, each with a house and garden, surrounded an open square, which served as a common milking place. Each lot tapered toward the center, where the house stood, and was widest on the periphery. The settlement was made up of several of these groups of lots. The other settlement pattern was made up of long, narrow lots, the size of which was determined by ease of plowing. In communes of this type the houses were usually placed in a row, the ribbonlike lots extending back from them. Both types were modified through the increase of population in the settlements. In both the street pattern has been made to conform to the original pattern of the lots. Hungary differs thus from western Europe, where the streets and roads determined the settlement pattern. In fact, in the ancient Hungarian language there was no word for street.

Dr. Michael Haltenberger compares the cultural geography of Eger and Gyöngyös, two cities in Heves County. Gyöngyös, the smaller city, serves as a commercial emporium for the farms, forests, and mines of the Mátra mountain region. Eger, the see of a bishop since the time of King Stephen, is an ecclesiastical city.

Dr. Béla Márton discusses the demographic trends of the Nyirség, an infertile, sandy region of northeastern Hungary, consisting of 158 communes in four counties. During the decade from 1920 to 1930 this region showed an increase twice as large as that of the entire country.

The six articles outlined above show the varied character of the collection, which is a cross section of present-day geographic studies in Hungary. In so far as theoretical treatment is attempted, these studies seem to offer only a slight contribution. Their value lies principally in their detailed investigation of local areas, especially areas of postwar Hungary.

E. D. BEYNON

THE MISSION FIELD OF THE OLD SOUTHEAST

JOHN TATE LANNING. **The Spanish Missions of Georgia.** xiii and 321 pp.; map, ills., bibliogr., index. (Publs. Univ. of Georgia.) The University of North Carolina Press, Chapel Hill, 1935. $3.00. 8¼ x 6 inches.

MAYNARD GEIGER. **The Early Franciscans in Florida and Their Relation to Spain's Colonial Effort.** 22 pp.; ill. St. Anthony Guild Press, Franciscan Monastery, Paterson, N. J., 1936. 25 cents. 9 x 6 inches.

Professor Lanning's work maintains the high quality that has characterized the researches into different aspects of early coastal Georgia and Florida, a territory known in the seventeenth century and earlier as Guale, Timucua, and Apalache.

Like many of its predecessors, this study has extended to the archival sources, which now, so far as the useful Spanish documents are concerned, the author believes have been fully examined. Heightened significance is thereby gained for the present study.

The author's task is not to authenticate disputed ruins (p. 237) as Spanish missions more or less vaguely located in the original documents but rather to present a truthful picture of the movement and the period. Such an objective has also typified the work of Bolton and Ross, to mention only two of the earlier contributors. This reconstruction is aided visually by decorative drawings of missions and mission scenes by Willis Physioc, based on documentary descriptions, and serving their purpose well. In place of an actual map of mission and presidio sites in their known or presumable locations there is included a folded maplike drawing, also decorative but scarcely adequate to meet the needs of the reader and falling short of conveying a fair understanding of the wealth of information mapped by other authorities.

The book is written by the skillful hand of one who not only has mastered the subject matter but is also aware of its dramatic possibilities. An opening chapter on the native tribes, identified by Swanton and Bushnell as of Muskhogean stock, helps to prepare the stage for the arrival of the first Jesuit missionaries in Guale, in 1566. Violent death having come to the remaining members of this pioneer group, the year 1573 brought the first Franciscans, under whose authority numerous missions were planted along the Gualean coast, especially on its islands and across the northern part of Florida to Apalache, the hinterland of the present Tallahassee. Despite occasional revolts by seminomadic Indians resentful of strict rules imposed on them by "the religious," the mission period extended until 1702.

Of special interest to the geographer is the implicit evidence of the close cultural connections between this coast and the West Indies. Equally significant are the early accounts, however sketchy, of the interior regions, especially Tama. The book should stimulate further research in the history and geography of these early regions. The lives and activities of the missionaries are recounted with such detail that one suspects that the same documents, culled from a different point of view, would yield much basic information concerning the early geography of the whole southeast coast. With respect to this detail, which extends even to conversations held as long ago as 1566, it is surprising that the book is not more fully documented.

In "The Early Franciscans in Florida" the author deals more specifically with the period from 1612 to 1702, "the golden age of Franciscan labor." Although emphasizing missionaries to the almost complete exclusion of missions, and without the aid of a map, the author nevertheless touches on several vital geographic items, especially the subdivisions of Guale as then recognized by its inhabitants and the unfavorable situation of St. Augustine, surprising in view of its early importance. The claim that at one time there were thirty thousand converted Indians within the mission field is probably overoptimistic, especially when viewed in the light of Kroeber's recent estimates of total Indian population.

RALPH H. BROWN

THE CIRCULATION OF THE WESTERN NORTH ATLANTIC

C. O'D. ISELIN. **A Study of the Circulation of the Western North Atlantic.** 101 pp.; maps, diagrs., bibliogr. *Papers in Phys. Oceanogr. and Meteorol.*, Massachusetts Inst. of Technology and Woods Hole Oceanogr. Instn., Vol. 4, No 4. Cambridge, Mass., 1936. $1.00. 11 x 8½ inches.

The problem of oceanic circulation is of basic importance in oceanography. As Iselin puts it, "it is, in fact, the necessity of taking into consideration the movements of the sea water which ties together the whole subject of oceanography." There has been great need for systematic observations in the deep waters of the western

North Atlantic for the purpose of arriving at an understanding of the circulation of the waters in this region. With the opening of the Woods Hole Oceanographic Institution in 1931, a program of such observations was inaugurated, and in the volume under review Iselin studies the circulation in this region as revealed from periodic temperature and salinity observations made by the Institution's research ship *Atlantis*.

The region covered by this study lies west of longitude 30° W., between the equator and latitude 50° N., except for the area round the Grand Banks, which is covered by the International Ice Patrol Service. After describing in an introductory section the equipment and methods used on board the *Atlantis* Iselin discusses the distribution of temperature and salinity in the area between Nova Scotia, Bermuda, and Cape Hatteras. Four distinct bands of water are found here: near the coast, the relatively fresh coastal water covering the continental shelf; farther eastward, slope water; next, the water of the Gulf Stream, which here has a width of about 130 miles; and, finally, the waters of the Sargasso Sea. The distribution of temperature and salinity in the waters of this area for different seasons of the year is presented by means of graphs, and the seasonal changes in the different bands of water are summarized.

The areas of the North Atlantic Current, the North Equatorial Current, the Antilles Current, and the Florida Current are then considered. The distribution of the temperature and salinity of the waters in these regions is discussed, and, more particularly, the temperature-salinity correlation. The Gulf Stream system, in view of its obvious importance, receives special consideration. The swiftness of this current makes subsurface observations difficult; hence the earlier observations brought out only the surface features of this system, which the more recent investigations prove to consist of three parts. Although the single name "Gulf Stream" serves for everyday use, particular designations for the component parts are necessary in a scientific study. Thus, the southernmost part—from the Straits to Cape Hatteras—is designated as the Florida Current; the name "Gulf Stream" is reserved for the middle part as far as the Grand Banks; and the North Atlantic Current is the name applied to the current eastward and northward from the Grand Banks.

In discussing the sources and character of the Gulf Stream system Iselin calls attention to the swift flow characteristic in the Florida Current and the Gulf Stream, which might be supposed to result from the confining effects of the Straits of Florida. He suggests, however, that the character of the current is greatly influenced by the northeasterly trend of the continental shelf of North America and adds that "even if the Straits of Florida did not exist, there would be a tendency towards a narrowing and intensifying of the broad circulatory movement initiated by the trade winds as the flow reaches the western margin of ocean and is forced to make a right angle bend to the north."

The final section of the study is devoted to the Sargasso Sea. This area Iselin regards as a shifting subdivision of the ocean, so that "the term has its greatest use when the area is not given too rigid bounds, but merely applied in a general way to the relatively slow-moving core of water around which the swifter flow of the great North Atlantic eddy revolves." Because of the shifting and variable nature of the climatic factors of this region, no surface feature can be regarded as even roughly marking the limits of this sea, except its northeastern boundary. Iselin suggests that the course of the 10° C. isothermobath for the depth of 700 meters is a most reasonable choice. With regard to the temperature-salinity correlation the waters of the Sargasso Sea are remarkably constant; hence the salinity anomalies furnish a sensitive criterion for tracing slow lateral seepages of water at mid-depth. From the data available Iselin finds two great movements of this type, which exert widespread influences. The layer centering at 1200 meters contains a slight admixture of Mediterranean water and is traced as far west as Bermuda. The relatively fresh

sub-Antarctic intermediate layer penetrates northward from the equator, a relatively strong concentration being observed in the Florida Current.

In this publication we have not only a considerable body of new data but also an integration of the observations pertaining to an important region of the sea for the purpose of elucidating its circulation. In correlating the data and in emphasizing the features that require further investigation this study serves also to focus attention on the salient factors of the complex problem.

H. A. MARMER

OCEANOGRAPHICAL WORK IN BERING SEA

Report of Oceanographic Cruise, United States Coast Guard Cutter Chelan, Bering Sea and Bering Strait, 1934. 72 pp.; maps, diagrs., ills., index. United States Coast Guard, Washington, 1936. 10½ x 8 inches.

This mimeographed report, compiled by Commander F. A. Zeusler, describes the varied oceanographic activities of the Coast Guard cutter *Chelan* in the summer of 1934. A prearranged schedule prepared by Commander Zeusler, commanding officer of the *Chelan*, assisted by the staff of the Oceanographic Laboratories of the University of Washington and approved by the commander of the Western Area and the Coast Guard Headquarters, was followed.

Bering Sea, second only to the Mediterranean in size, covers an area of 878,000 square miles. The eastern and northern parts are shallow, deeper than 100 meters in only a few places. The 100-meter contour extends from Unimak Pass in a northwesterly direction south of the Pribilof Islands to the east Siberian coast. The 1000 and 3000-meter contours lie southeast of the 100-meter contour and follow a direction roughly parallel to it. In most places the bottom drops more abruptly between 1000 and 3000 meters than between 100 and 1000 meters. The southwestern part is a basin with a uniform depth of about 3500 meters. Although the charts show that this basin is connected with the Pacific by a channel of the same depth between the Komandorski Islands and the Aleutian Ridge, recent observations by Commander L. V. Kielhorn (1936) indicate clearly that the Komandorski Islands are connected with the Aleutian Islands in much the same way as are the other island groups between the Alaskan and Kamchatkan Peninsulas. The ridge, or shoals, discovered by Kielhorn, is some twenty miles north of the soundings shown on present charts. The existence of such a barrier along the entire southern boundary of Bering Sea presupposes little opportunity for the exchange of the abysmal waters of Bering Sea and the North Pacific. Furthermore, observations show that Bowers Bank extends for a long distance in a general southwesterly direction, forming a great convex ridge westward from the 180th meridian. While engaged in these observations, Kielhorn, cruising into the North Pacific to extend previous soundings made by Zeusler, found that the "Aleutian Trough is much narrower, closer to the islands, and deeper than hitherto supposed" (7500 meters).

Where Bering Sea is connected with the Arctic Sea, the strait is 50 miles wide at its narrowest part and ranges from 40 to 60 meters in depth. There is thus a narrow path for the circulation of surface waters between Bering Sea and the Arctic Sea but not of deep water. This creates conditions for the North Pacific and Bering Sea that are vastly different from the conditions found in the North Atlantic, where the very deep water and the great expanse of ocean permit easy interchange of the waters of the Arctic and those of the Atlantic.

Water flows from the Pacific into Bering Sea through the many passes of the Aleutian Islands. In general, the waters of Bering Sea move north and empty into the Arctic Sea through Bering Strait, where the normal current is about two knots. This northward flow is substantiated by the movement of the ice that covers Bristol Bay and the northern part of Bering Sea in the winter. Protracted northerly gales

in the autumn change the direction of the current southward; but when the wind ceases, the current quickly sets to the north again. Strong southerly winds may increase the northward current to three knots. This northward movement has been substantiated by studies of the plankton, no "Arctic" copepods being found in Bering Sea. Cold water from the Gulf of Anadyr and perhaps some surface water from the deeper region of Bering Sea moved northward along the Asiatic coast and into the Arctic Sea on the west side of Bering Strait. Small eddy currents were found between St. Lawrence Island and the Diomede Islands. Calculated current velocities for the shallow waters of North Bering Sea are slow. These calculations gave only the relative velocities referred to the lowest observed level, and water at this level was shown by direct current measurements to be in motion.

In addition to discussing ocean-bottom topography and currents, the report brings together data on the temperature and chlorine content of the waters of Bering Sea and on the distribution of dissolved oxygen, phosphates, silicates, nitrates, and pH content.

Surface conditions en route from Seattle to Dutch Harbor are described, and the report includes interesting comments on the walrus, sea lion, sea otter, and fur seal. From all available information Commander Zeusler has prepared a chart showing the migration of the fur seal. Pages 50 to 67 are devoted to a review of the numerous observations made by various explorers and by officers of the Coast Guard on the appearance and condition of Bogoslof Island. THOMAS G. THOMPSON

THE GEOGRAPHICAL CLASSIFICATION OF CLIMATES

W. KÖPPEN. **Das geographische System der Klimate.** 44 pp.; maps, diagrs., bibliogr., index. (Handbuch der Klimatologie, Vol. 1, Part C.) Gebrüder Borntraeger, Berlin, 1936. 10½ x 7 inches.

The great five-volume handbook of climatology edited by Köppen and Geiger and published in sections is well on its way toward completion. Volumes 2 and 3 are nearly finished, and, quite fittingly, Volume 1 has just been concluded with a discussion by Professor Köppen of the geographical classification of climates.

Köppen's classification has become well known in this country through reviews, critical appreciations, and elaborations and through its adoption, in modified and simplified form, in several recent American geographical textbooks. It is not a genetic classification, since it leaves complex climatic causes practically out of consideration; but it is based on simple climatological facts, such as average monthly temperatures and seasonal rainfall. Köppen attempts to choose, so far as possible, limits that show a parallelism with certain phenomena of the organic world. He particularly seeks correlation with the varying aspects and the distribution of plant life, since vegetation, because of its complexity and relative immobility, is very sensitive to differences of climate. In its further implications this probably explains the favor the scheme has found among geographers.

Köppen's intention was to establish a classification applicable to the entire world and susceptible of regional comparisons, but he had to limit himself to generally available data. Thus his classification was built primarily on a combination of temperature and precipitation characteristics. Although it is undoubtedly highly desirable that such factors as evaporation and radiation should be taken into account, the quantitative measurement of these two involves considerable difficulty, and few comparable data are available at present. Similarly, because of the close correlation with vegetation, data on ground temperatures and soil moisture may be significant, but on both of these statistical information is practically nonexistent. However, in the near future more complete and more dependable information on the average length of the growing season may make it possible to improve on some of the subdivisions in the middle latitudes.

Some day it may be possible to draw up a classification giving more attention to the direct relationship between climate and man, a classification that, for example, would take into account "sensible" temperatures. Such a scheme would be a useful pendant to Köppen's classification.

With the data at hand Köppen's classification is undoubtedly the best we have. It has the great advantage that its basic system is simple, though not so simple that it suffers from some of the unwarranted generalizations of, for example, Herbertson's scheme. Minor differences of climate can easily be brought out by adding letters to the capitals chosen as designations for the main divisions. Probably the only important weak point of the system is the delimitation of the steppe and desert areas. This is partly the result of the insufficiency of relevant data and the variable, extremely localized precipitation in the nonhumid regions, which made it very difficult to draw up an entirely satisfactory empirical formula; and it is partly the result of the repeated changes that Köppen has made in the formulae used for determining the *Trockengrenze*, which have tended to cause some confusion. The formula of 1922 was not satisfactory, at least not for North America, as Russell and the reviewer have tried to show. On the other hand, the formula adopted in 1928 and used throughout the handbook seems to go a little too far in the other direction.

WILLIAM VAN ROYEN

THE WORLD'S WHEAT

M. K. BENNETT AND HELEN C. FARNSWORTH, with the assistance of P. Stanley King and Rosamond Peirce. **World Wheat Acreage, Yields, and Climates.** Maps, diagrs. *Wheat Studies of the Food Research Institute*, Stanford University, Cal., Vol. 13, 1936–1937, pp. 265–308. $1.25.

Geographers in particular will welcome this comprehensive study, one of a justly renowned series on the cereal that covers a larger area than any other crop sown and harvested by man. In this publication, for the first time, postwar (1920–1934) yield and acreage data are presented in map and tabular form for 257 wheat-growing areas, including the often neglected China and Turkey. Map A is especially noteworthy in that the dots used to show acreage distribution are in seven colors to represent different average yields. Fairly comprehensive analyses of the distribution of acreage and average yields in relation to geographic factors, especially climate, have been included.

Section I deals with the broad aspects of postwar acreage distribution, by hemispheres and continents, by countries and wheat belts, and by varieties and levels of yields. In Section II, on acreage distribution by climates, not only are general latitude and rainfall-zone contrasts utilized but Thornthwaite's classification (slightly modified) is also employed, and the results are summarized in millions of acres.

	A′ TROPICAL	B′ MESO-THERMAL	C′ MICRO-THERMAL	TOTAL
B Humid	..	34	25	59
C Subhumid	16	115	83	214
D Semiarid	..	48	46	94
Total	16	197	154	367

Competition with other crops has been adequately considered, and the conclusion is that the most favorable competitive position for wheat seems to be found in a subhumid mesothermal climate, on both its drier and its cooler margins.

Section III, on the geographic and climatic distribution of yields, presents frequency distributions of average yields weighted and unweighted, by millions of acres, number of areas (257 total), yield groups, climates, and specified climatic elements. No conclusive evidence is found in this study to support the statement sometimes made by geographers as a general principle that the yield of crops increases from the equator to the coldward limits of production. In Section IV the isopleth climograph is used to analyze yield as related to annual and preharvest precipitation and temperature. The results obtained indicate the following approximate optima: annual precipitation, 25 to 35 inches; preharvest precipitation, 3 to 6 inches; annual temperature, 45° F.; preharvest temperature, 58° to 60° F.

Both the appendix notes and the footnotes will be of particular utility to the careful student of this problem, for they deal with the limitations of the data and methods used. The publication is much too meaty to be easy reading and yet boiled down into these brief pages is without question the outstanding recent contribution to the geography of world wheat production.

JOHN KERR ROSE

GEOGRAPHICAL CAUSALITY

E. MARKUS. **Geographische Kausalität.** *202 pp., maps, diagrs., ill., bibliogr. Acta et Commentationes Universitatis Tartuensis (Dorpatensis) A 30, 5.* Tartu, 1936.

The author seeks to establish a methodology whereby one may derive (1) those fundamental principles that, when active, always produce the same results and (2) those elements that yield differing effects and thus do not yield general principles. He operates through a series of microcosmic studies to provide comparative data from which ultimate principles may be derived. His approach harmonizes with the philosophy of some American geographers who hold that an ultimate geographic interpretation of extensive regions must be preceded by chorographic studies. Apparently Markus' investigation was stimulated by Hettner's emphasis on chorology, to which he refers as marking a "new epoch in the field of geographic causal relationships." Through analyses of climatic, ecologic, physiographic, and cultural situations he seeks to work out a quantitative approach to "geographic causality."

That there is or may exist a harmony of relationships, or rhythm, is illustrated by given landscapes. Harmony is greatest when some single element such as climate is dominant and brings all the other phenomena into conspicuous and obvious dependence on it. Such is the situation in the tropical rain forest, where river stage, formation of natural vegetation, lower animal life, and the activities of man show a direct response to the climatic environment. Rhythm is expressed in seasonal characteristics reproduced at fixed intervals. In a cultural landscape man is largely the causal factor: however, nature delimits many of the changes that man may effect, such as the kinds of crops he may bring to maturity and in some instances the materials he may derive from local natural resources.

A phase of geographic causality involves "chorogenesis," namely a study of the origin and evolution of a natural complex, or landscape. As applied to landscapes, chorogenesis calls for the investigation of a landscape as a unit rather than in terms of the morphology of its parts. As viewed by the geographer it becomes essentially a historical geography of a landscape.

In essence this volume develops a case for an approach to the science of geography through the process of successive collecting, analyzing, and synthesizing of data bearing on such phenomena as the geographer wishes to interpret.

EUGENE VAN CLEEF

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